

Competitiveness and Innovation

Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland

Technical Report 3

**Study on Productivity, Innovation and Competitiveness
in Small Open Economies**

February 2010

Bradford University School of Management

Manchester Institute of Innovation Research, Manchester Business School

Department of Economics, University College Cork

Preface

Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland is the third of four reports produced by the study on Productivity, Innovation and Competitiveness in Small Open Economies (PIC SOE). The PIC SOE project is a research study commissioned by the Department of Enterprise, Trade and Investment (DETI) in 2009 to investigate approaches and strategies for advancing productivity, innovation and competitiveness in the three leading small open economies of Singapore, New Zealand, and the Republic of Ireland so as to draw insights for Northern Ireland.

The PIC SOE project is undertaking economic performance, industry, and policy analyses of these small open economies and of key sectors within them, including emerging technology industries, chemicals, processed food, and advanced services. Three technical reports are being delivered: 1. *A Comparison of Northern Ireland's Productivity and Efficiency across Services and Manufacturing*; 2. *Mapping Organizational Capabilities for Innovation and Competitiveness: Research Performance and Patenting in Small Open Economies*; and 3. *Competitiveness and Innovation Profiles of Three Small Open Economies: New Zealand, Singapore, and Republic of Ireland* (this report). A final report, *Productivity, Innovation and Competitiveness in Small Open Economies*, will provide an overview of the findings of these earlier reports and assesses the applicability, comparability, and significance of the findings for policy development in Northern Ireland to support the region's prosperity, innovativeness, and industrial productivity.

The PIC SOE study team comprises: Dr. Adrian T.H. Kuah (University of Bradford, UK); Prof. Philip Shapira (Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, UK); Dr. Eleanor Doyle (Institute for Business Development and Competitiveness, Department of Economics, University College Cork, Republic of Ireland); and Dr. Damian R. Ward (University of Bradford, UK). Additional research assistance is provided by Lasandahasi Ranmuthumalie de Silva, Fergal O'Connor, Gary Marsh and Luciano Kay.

This report profiles the competitiveness of the three benchmark economies, undertakes an analysis of factors underlying competitiveness for small open economies, and presents observations and findings from our case studies of Singapore, New Zealand, and the Republic of Ireland. The report was written by Eleanor Doyle, Adrian Kuah, and Philip Shapira. Any opinions, findings, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of DETI. Some information and analyses included in this report have been updated prior to use in the PIC SOE final study report.

Contents

Preface	i
Contents.....	ii
List of Figures	iv
List of Tables	iv
Executive Summary	v
1. Introduction	1
2. Competitiveness Profile of Small Open Economies	2
2.1 Components of Competitiveness Pillars	3
2.2 National Competitiveness Performance	5
Singapore	6
New Zealand	9
Republic of Ireland	11
2.3 Discussion:	13
3. Innovation Capacity Profile - SOEs	15
3.1 National Innovative Capacity Framework.....	16
3.2 Empirical Analysis.....	17
Test of Parameter Stability	18
3.4 National Patent Stock and Level of Economic Development	19
3.5 Discussion.....	20
4. Business and Policy Environments Impacting SOE Productivity, Innovation and Competitiveness.....	23
4.1 Business & Policy Environment - New Zealand.....	24
Food Processing	25
Advanced Manufacturing and Materials	29
Financial Services (and Advanced Business Services)	32
Findings	35
4.2 Business and Policy Environment of Singapore	37
Financial Services (and Advanced Business Services)	37
Food Processing	40
Chemicals Sector	42
Emerging Sectors	44
Government Insights.....	47
Findings	49
4.3 Business and Policy Environment – Republic of Ireland	51
Financial Services (and Advanced Business Services)	51

Chemicals, Pharmaceuticals and Emerging Biotech	55
Food – Distribution, Logistics and Processing.....	59
Findings	62
5. Conclusions and Further Discussion.....	66
5.1 Competitiveness and Innovation	66
5.2 Insights from Field Research	68
New Zealand	69
Singapore	70
Republic of Ireland	72
6. References - Academic Publications.....	77

List of Figures

Figure 1: The Twelve Pillars of Competitiveness	4
Figure 2: National Innovative Capacity Framework	17
Figure 3: Agencies of MTI: Singapore	47
Figure 4: R&D Spending Comparisons – Singapore	48
Figure 5: Republic of Ireland - Location of Business Agglomerations	64

List of Tables

Table 1: Weightings of Competitiveness Components and Stage of Development	4
Table 2: Competitiveness Measures, Selected SOEs: 2005-6 to 2009-10	5
Table 3: Global Competitiveness Index and Components: Singapore	8
Table 4: Global Competitiveness Index and Components: New Zealand	10
Table 5: Global Competitiveness Index and Components: Republic of Ireland.....	12
Table 6: Determinants of Patent Output, 1993-2008: Alternative Specifications ...	22

Executive Summary

In this report we examine aspects of the competitive and innovative environments of Singapore, New Zealand and the Republic of Ireland firstly by analyzing competitiveness and innovation capacity using secondary data derived from published sources and secondly on the basis of field interviews carried out with 79 participants over our three locations.

We examine the competitiveness profiles of Singapore, New Zealand and the Republic of Ireland, 2005-2010 outlining the main competitiveness drivers and barriers based on hard and survey data compiled for the Global Competitiveness Project of the World Economic Forum, organized around twelve competitiveness pillars. We also estimated three alternative complementary approaches to the determinants of innovative capacity allowing us to identify the most significant determinants of patenting outcomes for 23 economies 1993-2005. We investigate whether smaller economies, including Singapore, New Zealand and Republic of Ireland, are supported or hindered by their limited scale or low critical mass in achieving innovative success. On the basis of our field work we examine the general and immediate business environment and the institutions and processes promoting national productivity to understand how businesses, research and policy organizations take up the challenges of improving productivity, innovation and competitiveness at meso- and micro-levels. Our analysis finds that:

- Over 85% of variation across countries' levels of living standards (GDP per capita) is explained by the elements of the twelve competitiveness pillars. Singapore is ranked most competitive of our 3 countries as 5th of 131 countries (on average 2005-2010). New Zealand's average rank is equivalent to that for the Republic of Ireland at 22. Quite different profiles emerge from examining the sub-components of the indices.
 - Singapore ranks in the top 3 for Basic Requirements - indicating its institutions, infrastructure, macro-economy and health and primary education support a productive economy, and similarly for Efficiency Enhancers – measuring higher-order productivity inputs including higher education, technological readiness and market efficiency. Its performance in Innovation and Sophistication is relatively weaker but in the top 12. Despite recent improvements in its rankings in Business Sophistication, weaknesses remain in local supplier quantity, and quality, and for control of international distribution channels.
 - New Zealand is ranked similarly at 17 for Basic Requirements and Efficiency Enhancers. Relative performance in Innovation is weaker at 26. Its Business Sophistication ranking has declined (explaining the decline in its overall ranking for Innovation and Sophistication) with specific areas of most concern including local supplier quantity, state of cluster development and nature of competitive advantage (focussed more on low cost and resource-based rather than unique products or processes).
 - Republic of Ireland is ranked at 27 for Basic Requirements (with particularly weak Infrastructure rankings) and at 19 for Efficiency Enhancers. Its Innovation ranking is 20. Its Innovation-related weaknesses relate to local supplier quantity, control of international distribution and state of cluster development.

- Our investigation of drivers of Innovative Capacity reveals that SOEs use the same basic principles (or model) as the 'average' advanced economy in patents generation, with some qualifications.
 - R&D expenditure was the most economically (and statistically) significant determinant of patent activity. A 10% increase in spending results in a 4.8% to 5.5% increase in patent production for the full sample with larger impacts of between 6.7% and 7.5% for SOEs.
 - *Legal Structure and Security of Property Rights* and the *Openness* of an economy to international trade are significant explanatory factors with a 10% increase in the perceived level of Property Protection resulting in approximately a 1% increase in patents for the full sample and over 3% for our SOEs. For *Openness*, we find a 50% greater impact on patent production in SOE's relative to the average sample at over 2%, given the estimate of 1.4% for the full sample.
 - As indicated by the constant term in the estimation, efforts to achieve the first patent are greater for SOEs, approximately 50% greater than for the overall sample.
- Our field analysis of the business and policy environment across our cases revealed that:

Macro-economic Foundations

- Market liberalization is a necessary but not sufficient condition for county success in globalized competition.
- Investments in human capital, R&D, and infrastructure are critical in building the foundation for high-value economic growth.
- Investments in infrastructure and education over a prolonged period, supplemented by the influx of foreign talents, are critical to economic growth.
- In exploring a new economic model, learning and un-learning may be required. There is a need to learn how to manage intangible assets, i.e. the idiosyncratic sentiments of people including foreign talent.
- Success in attracting FDI creates new growth opportunities for outward oriented companies. Changing the focus of value-added activities of businesses from manufacturing to more innovation-intensive is to be supported through active collaborations.
- Evolution and integration in policy focus to support a changing economy is required.

Targeted Strategies

- Traditional sectors can have significant potential for innovation and export-led growth.
- Small economies can achieve success in emerging high-technology sectors through well-focused targeting of resources
- The encouragement of global-local strategies in public as well as private sectors is an important aspect of innovation strategy in a small open economy.
- FDI and export-oriented growth is strengthened by internationalization of domestic firms.
- Internationally competitive MNCs generate both direct and indirect economic benefits.

- The challenges for domestic businesses in an Export-Platform economy can be addressed with policy supports.
- Innovation goes beyond Science and relies as much on input from, and funding for, entrepreneurs, salespeople, managers and consumers.

Organizational Design

- Redesign in the role and function of research institutes is a critical ingredient in innovation-led development. Where research institutes, including those of universities, are most effective in fostering innovation, including in the primary sector and in key high-technology sectors, common factors appear to be organizational reform, leadership, the development of tighter linkages between researchers and industry, and specific initiatives to disseminate results.
- Well-designed innovation initiatives can reach traditional manufacturing sectors and induce significant spillovers.
- Well designed innovation and spill-over initiatives are core to policy implementation.
- The government and its agencies operate like a business in their thinking and approach.
- Strategies driven from the top can work with participation from key business partners
- Effective roll-out of technology transfer functions from universities takes time to implement and to become an embedded feature of the economy.
- Engagement and meaningful implementation of ‘cluster’ type policies result in impacts extending beyond agglomeration. Innovative thinking on the relevant implications of clusters for SOEs, incorporating perhaps greater international collaborations, is also required.

Governance and Evaluation

- Open and transparent governance, and government’s broad orientation to learning and evaluation, are important aids in the effective development and improvement of competitiveness and innovation policies.
- Active public-private exchange is important in developing strategies for targeted sectors.
- Closed governance with meritocratic system of talent selection and pipeline development is central to the Administrative Services.
- Strategies and projects focus on finding “the next big thing”; many successes and some failures result but the small size of the country enable fine-tuning of focus and agile strategies to ensure winners are identified and losers quickly sieved out.
- Consistent and ongoing evaluation of programmes underpins the selection of interventions for support, Openness in sharing results generated through evaluation processes indicates confidence of agencies in sharing learning, where appropriate.
- Analysis of the broad policy orientation and its impact should be based on well- specified criteria.
- Innovation that generates economically viable products, processes and new businesses goes beyond a ‘high-tech’ definition.

1. Introduction

The foundations of economic productivity in modern developed economies are Competitiveness and Innovation. Conventional understandings on the role of macroeconomic policies identify them as necessary if insufficient to generate growth and prosperity. At the best of times policy makers and business leaders are confronted with challenges for economic management. The current economic environment heightens these challenges, particularly for small regional economies, such as Northern Ireland, largely dependent on interactions with their close neighbours and their broader network of international economies for their prosperity and growth. This Report is an attempt to increase our understanding of the fundamental competitive positions of the small open economies selected for the purposes of this research within their global economy context with a view to considering what lessons might be learned from their experiences in economic development terms.

Section 2 of the Report outlines the Competitiveness Profile of the small open economies of New Zealand, Singapore and the Republic of Ireland. The approach to measuring and analysing competitiveness follows that used in the Global Competitiveness Project of the World Economic Forum from which the data and rankings presented are sourced. The underlying method for the project is explained and comparative performance across the three main categories of the Global Competitiveness Index (GCI) i.e. Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors are examined for our three selected economies. This adds to our understanding of the relative strengths and weakness of competitiveness attributes for each economy and we highlight those that may be most problematic for improving competitiveness.

In Section 3 we analyse innovation performance in further detail where the Innovative Capacity Performance of Small Open Economies (SOEs) is explicitly examined. The analytical approach is in line with that applied in the Section 2, based on a comprehensive definition of and approach to competitiveness. The method of panel estimation of alternative models determining innovative output used here allows us to identify the most statistically significant explanatory variables for innovation activities cross 23 developed modern economies 1993-2005. From the perspective of small open economies, we are keen to identify if there are statistical differences in national innovative capacity relative to other developed modern economies, and the determinants of most importance.

In Section 4 we outline our assessment of the general and more immediate business environment and the institutions and processes promoting national productivity, innovation and competitiveness in each of our selected economies of Singapore, New Zealand and The Republic of Ireland. There are differences in performance and strategy by different sectors in each country and it is also important to understand how businesses, research organizations, and policy organizations take up the challenges of improving productivity, innovation and competitiveness at the meso- and micro-levels. These topics are addressed in our case studies of each economy. From interviews with policy makers, business advisory

agencies, industry and academic experts and business practitioners we profile the substance and experience of policies and programmes to foster enterprise productivity, innovation, and competitiveness to consider the lessons and best practice insights that can be garnered in our final phase of this study. We chose a mix of sectors to represent a broad range of the economies, including high-end emerging sectors to more traditional industries serving the domestic economy.

Section 5 offers our conclusions to be integrated with those from earlier reports and the results of field work to be conducted in Northern Ireland in the next and final phase of our study.

2. Competitiveness Profile of Small Open Economies

Following the approach in the Global Competitiveness Project of the World Economic Forum, **the term 'competitiveness' includes a broad range of factors, policies and institutions, that ultimately determine the level of productivity of an economy.** Hence, competitiveness is essentially focused on economic productivity. More competitive and productive economies tend to have the capacity to produce higher levels of income for their citizens. The productivity level also determines the rates of return obtained by investments and since the rates of return are fundamental drivers of economic growth, a more competitive economy is one that is likely to grow faster in the medium to long run.

Since 2005, the World Economic Forum has based its competitiveness analysis on the Global Competitiveness Index (GCI), a comprehensive index capturing both microeconomic and macroeconomic foundations of national competitiveness across twelve 'competitiveness pillars'. The index is largely attributable to the work of Michael Porter who co-directed the Global Competitiveness Report (until 2009) and who leads the Institute for Strategy and Competitiveness at the Harvard Business School. Availability of data across 2005-2009, notwithstanding some changes and developments to the index, allows us to draw some comparisons over the period 2005-2010, for which the GCI data are available.

A relatively strong score and ranking in the GCI indicates an economy possesses a combination of productivity-enhancing features such as:

- a strong and sophisticated business culture - both in terms of companies and customers,
- well developed infrastructure,
- close collaboration between industry and universities/research centres in research,
- high business spending on R&D,
- a high capacity for innovation,
- strong protection of intellectual property,
- respect for the rule of law and an efficient judicial system and
- generally transparent and accountable institutions.

Sound macroeconomic foundations are a necessary, if insufficient, condition for an overall high ranking.

The concept of competitiveness is arguably broad and encompasses a range of productive factors. It is impacted by policy and business decisions and is also influenced by requirements to meet legal and self-imposed norms (e.g. business strategy goals). Despite these inherent sources of complexity, the approach to its measurement in the Global Competitiveness Index (GCI) rests on solid theoretical foundations. Each of the twelve separate 'competitiveness pillars', outlined in Figure 1, is measured and selected for inclusion in the GCI based on the latest international theoretical and empirical research on the determinants of productivity and prosperity. **The GCI integrates determinants of the current level of productivity, which largely controls an economy's level of income, and an economy's ability to sustain its income through returns generated from investments that influence its potential to grow.**

2.1 Components of Competitiveness Pillars

The twelve competitiveness pillars are arranged under three main headings or categories to provide an indication of countries' relative positions in relation to

- Basic Requirements,
- Efficiency Enhancers and
- Innovation and Sophistication Factors.

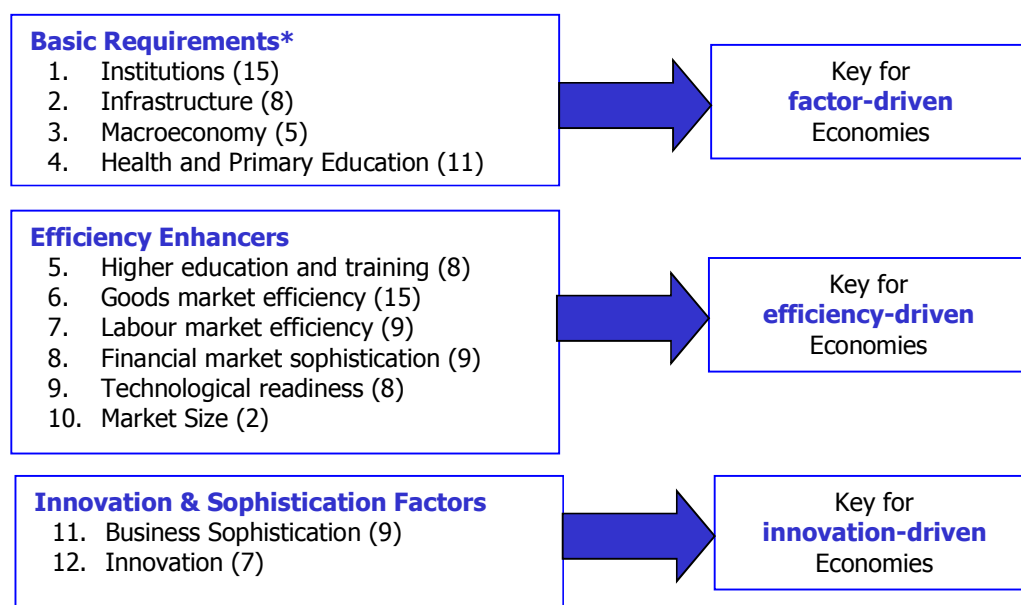
Hard statistical data coupled with responses to an *Executive Opinion Survey* are the sources for measurement of each of the pillars and 110 separate measures enter into the Global Competitiveness Index with a minimum of 2 measures for the Market size pillar feeding into Efficiency Enhancers, 5 measures for the Macroeconomy pillar under Basic Requirements to a maximum of 19 measures entering to the Institutions Pillar (one of the Basic Requirements categories) and 15 measures for the Goods Market pillar under the Efficiency Enhancers category (see Appendix for complete listing of measures per pillar).

The role of each competitiveness pillar (and its sub-elements) is not independent of other pillars (or elements), as some competitiveness factors are enhanced and supported by others (and the corollary also holds that some factors are dragged down or hindered by poor outcomes of other competitiveness features) pointing to the interdependence of many of the components in the index and the complexity of the competitiveness concept.

The framework outlined in Figure 1 is founded on the view that **the most important features driving productivity varies with the stage of development of an economy** (as presented in Table 1). The implication is that in the most developed or high-income economies the weighting, for example, for innovation and business sophistication is highest (at its maximum weighting of 30%). For the lowest-income economies the emphasis is on Basic Requirements (60%), while for middle-income efficiency-driven economies, basic requirements are weighted lower at 40% and this declines to 20% for the richest economies. For both middle and high-income economies, the factors grouped as Efficiency Enhancers

account for 50% in the weightings and the weightings of Innovation and Sophistication Factors are 10% and 30% for these economies respectively.

Figure 1: The Twelve Pillars of Competitiveness



Note: * Figures in parentheses indicate the number of measures used in measuring each pillar.¹

Different weightings are used for each of these sub-indexes in the computation of each country's Global Competitiveness score for the index, depending on its level of income, assumed to reflect its level of economic development.

Table 1: Weightings of Competitiveness Components and Stage of Development

GCI Sub-index	STAGE OF ECONOMIC DEVELOPMENT		
	Low income	Middle income.....	High income
	Factor-driven stage (%)	Efficiency-driven stage (%)	Innovation-driven stage (%)
Basic Requirements	60	40	20
Efficiency Enhancers	35	50	50
Innovation & sophistication factors	5	10	30

Source: Table 1, Chapter 1.1 in the *Global Competitiveness Report 2009-10*, Palgrave Macmillan.

¹ Figure adapted from Figure 1, Chapter 1.1 in the *Global Competitiveness Report 2007-8*, Palgrave Macmillan.

The small open economies (SOEs) included in this project (New Zealand, Singapore, The Republic of Ireland), and the economy of Northern Ireland, given their levels of income per capita, find themselves among the elite group of countries defined as producing and trading in an innovation driven stage of development. In the case of each economy, the relevant weighting is 50% on Efficiency Enhancers, 30% on Innovation & Sophistication Factors and the remaining 20% on Basic Requirements.

High-income SOEs at the focus of this study, located in the innovation-driven stage of economic development **will be able to generate and sustain higher wages associated with relatively high living standards only if their businesses are able to compete through unique and new products and services.** Clearly the extent to which this is achieved depends on the quantity and quality of resources and skills fundamental to innovation - analysis, problem-solving, creativity and resourcefulness. This requires inputs arising from Science and Technology-focussed policies and business strategies, however, it equally requires a sophisticated understanding of what makes consumers tick, grounded in and drawn from social and behavioural sciences and business practice. The institutions supporting this upgrading process of resources, skills and business strategies also play a direct role in the development outcomes.

2.2 National Competitiveness Performance

In Table 2, the performance of the SOEs according to the GCI is presented for each of the years since 2005-6 to the most recently available data for 2009-10, the period for which comparable data (following the same underlying method) are available. The overall rankings reveal general trends in the competitiveness performance of the selected economies, with Singapore ranking highest over the period considered at 3 in 2009-10, and with its lowest ranking of 7 in 2007-8. It remains the highest-ranked Asian country in the index over the period considered here.

Table 2: Competitiveness Measures, Selected SOEs: 2005-6 to 2009-10

	GCI 2009-2010		GCI 2008-2009		GCI 2007-2008		GCI 2006-2007		GCI 2005-2006	
Country	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Singapore	3	5.55	5	5.53	7	5.45	5	5.63	5	5.67
New Zealand	20	4.98	24	4.93	24	4.98	23	5.15	22	5.22
Republic of Ireland	25	4.84	22	4.99	22	5.03	21	5.21	21	5.22
Top Score		<i>5.60</i>		<i>5.74</i>		<i>5.67</i>		<i>5.81</i>		<i>5.85</i>
# countries		<i>133</i>		<i>134</i>		<i>131</i>		<i>125</i>		<i>117</i>

Source: *Global Competitiveness Report*, various editions, World Economic Forum, Palgrave Macmillan.

New Zealand and the Republic of Ireland were quite similarly ranked in the initial year, at 22 and 21 respectively, and their performances remained in the high to mid

twenties over the period although most recently, the Republic of Ireland's performance declined and its most recent ranking is 25, while New Zealand's most recent ranking of 20 was an improvement of 4 positions from the previous year. The most recent rankings can be interpreted in the light of the international recession and a measurable decline in average scores since last year has been observed for all countries in the GCI (Global Competitiveness Index) with those most adversely affected (e.g. Republic of Ireland) displaying greater declines in their rankings.

To analyse each country's performance in more detail Tables 3 to 5 offer the results for Singapore, New Zealand and the Republic of Ireland respectively for each of the three main stages-of-development headings - Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors - and further present rankings and scores for each of the twelve competitiveness pillars on a country by country basis. Reporting on a more disaggregated basis is useful in the sense that it gets closer to the specific areas in which a country needs to improve.

Singapore

Rankings and scores for Singapore's competitiveness pillars are provided in Table 3 with the breakdown for each category of Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors presented in panels A, B and C in the Table.

Basic Requirements

Singapore consistently ranked in the top 3 countries based on the quality of its Institutions, Infrastructure, Health and primary education, and Macroeconomic stability. Property and intellectual rights protection is very strong, corruption is not problematic, there is transparency in government policymaking, and there is trust in the ethical standards of its politicians, ranked highest in 2009-10.² Public spending is focused on purposeful goods and services (i.e. not considered wasteful by the business community) and the burden of governmental administrative requirements is not considered burdensome (both ranked highest in 2009-10). The only indicator for which Singapore ranked outside the top 10 relates to business costs of terrorism where the threat of terrorism is considered to impose substantial costs - here the country ranked 79 of 133. For such a small economy sandwiched between larger Malaysia and Indonesia, there are limitations regarding what it could do to mitigate its geographical disadvantage, except for more collaborative alliances with its neighbours in investments.³ Singapore scored second only to Switzerland for Infrastructure in most recent rankings and rates in the top 6 over time. Regarding Health and primary education Singapore's position has improved considerably over the 5 year period and is currently ranked 13. Macroeconomic stability performance has declined from

² The rankings for the various sub-elements of each competitiveness pillar are not presented here to conserve space but all can be found in the relevant Global Competitiveness Reports.

³ Brown (2006: 5) points out that the Singapore-initiated investment strategy in the growth triangle in Riau, Batam, and Johor between 1989 to 1994 has generated capital flows from Indonesia, Malaysia and regions in the US and Europe (notwithstanding the number of trade agreements with various countries mentioned in the Section 4 later). As a result, Singapore acted as an important financial conduit for investment houses and Western banks to tap into the growth triangle, in particular.

a top ten ranking to reach 24 in 2007-8 and fell to 35 in most recent results.

Efficiency Enhancers

Consistent strong performance for all but the market size component underlies Singapore's top 6 ranking here. Singapore has grown in tandem with industrialisation, shipping and the accelerated economic changes in South East Asia since 1980. Its markets function freely and pro-competitively. FDI is a key source of new technology for Singapore's firms as the country reaped rewards from its industrialisation programme over the last thirty years. Laws relating to IT usage are well developed with the focus and development of the Infocomm Development Agency (IDA)⁴, resulting in strong performance under the heading of 'technological readiness' which offers an indication of the availability and capacity for absorption of new technologies.

Innovation and Sophistication

Despite its strong performance across the above two categories, it is only in the current year's results that Singapore enters the top 10 in rankings for Innovation and Sophistication. A top 11 ranking is achieved over the period for Innovation indicative of the ability of companies to conduct research and pioneer new products/processes (supported by substantial investments in R&D in recent years with the creation of ASTAR) and possessing institutions to support innovative activities with required teams of expertise. In terms of government decisions fostering technological innovation, Singapore ranked highest in most recent results. Relatively weaker performance is evident in Business Sophistication with a rank of 60 for control of international distribution, 44 for local supplier quantity and 28 for local supplier quality. More positive rankings were measured for cluster activity, described as prevalent and well-developed (ranked 5) and firms competing on the basis of unique products and processes (ranked 13) in 2009-10.

⁴ The Infocomm Development Agency (IDA) is a statutory board formed in 1999 when the government merged the National Computer Board (NCB) and the Telecommunication Authority of Singapore (TAS) as a result of their growing convergence. The mission is "to develop the infocomm cluster as a major engine of growth and to leverage infocomm for economic and social development" partially through the Intelligent Nation 2015 (iN2015) Masterplan.

Table 3: Global Competitiveness Index and Components: Singapore

	GCI	(A) Basic Requirements Rank (Score)	(B) Efficiency Enhancers Rank (Score)	(C) Innovation & Sophistication Rank (Score)
05-06	5	3 (6.05)	2 (5.70)	14 (5.24)
06-07	5	2 (6.13)	3 (5.63)	15 (5.11)
07-08	7	3 (6.08)	6 (5.38)	13 (5.14)
08-09	5	3 (6.14)	2 (5.52)	11 (5.16)
09-10	3	2 (5.99)	2 (5.61)	10 (5.15)
Weighting in GCI		20%	50%	30%

(A)	Basic Requirements	Institutions	Infrastructure	Macro-stability	Health/Prim edn
05-06	3 (6.05)	1 (5.92)	5 (6.19)	9 (5.48)	69 (6.60)
06-07	2 (6.13)	4 (5.90)	6 (6.16)	8 (5.67)	20 (6.81)
07-08	3 (6.08)	3 (6.03)	3 (6.36)	24 (5.68)	19 (6.24)
08-09	3 (6.14)	1 (6.19)	4 (6.39)	21 (5.74)	16 (6.24)
09-10	2 (5.99)	1 (6.15)	4 (6.35)	35 (5.24)	13 (6.22)

(B)	Efficiency Enhancers	Higher Ed & Training	Gds mkt eff*	Lab mkt eff*	Fin Mkt soph*	Tech read	Mkt Size**
05-06	2 (5.70)	8 (5.68)	4 (5.59)			1 (5.82)	
06-07	3 (5.63)	10 (5.59)	4 (5.62)			2 (5.69)	
07-08	6 (5.38)	16 (5.42)	2 (5.76)	2 (5.67)	3 (6.02)	12 (5.36)	50 (4.06)
08-09	2 (5.52)	8 (5.56)	1 (5.83)	2 (5.71)	2 (5.94)	7 (5.64)	41 (4.41)
09-10	2 (5.61)	5 (5.62)	1 (5.77)	1 (5.91)	2 (5.91)	6 (5.90)	39 (4.53)

*In 2005-2006 the method applied in assessing market efficiency included the markets goods, labour and finance together under one competitiveness pillar. In later years these were separated into separate pillars.

**This pillar was included as a pillar of competitiveness in an improvement to the underlying methodology in 2007-08.

(C)	Innovation & Sophistication	Business Sophistication	Innovation
05-06	14 (5.24)	20 (5.30)	9 (5.18)
06-07	15 (5.11)	23 (5.17)	9 (5.04)
07-08	13 (5.14)	16 (5.19)	11 (5.08)
08-09	11 (5.16)	14 (5.25)	11 (5.08)
09-10	10 (5.15)	14 (5.20)	8 (5.09)

Source: *Global Competitiveness Report*, various editions, World Economic Forum, Palgrave Macmillan.

New Zealand

Rankings and scores for New Zealand's competitiveness pillars are presented in Table 4 with the breakdown for each category of Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors presented in panels A, B and C in the Table.

Basic Requirements

New Zealand's consistency in a top 20 ranking in this category is driven by top ten scores for Institutions and Health and primary education (excluding the outlier in 2005-06). Its corporate ethics were ranked 1 in 2009-10, as was the strength of auditing/reporting standards, judicial independence, and also the protection of minority shareholders' interests. The poorest ranking (53) here was found for the threat posed by terrorism for business costs. For the share of national income devoted to Health expenditure the country ranks 11, the quality of education is ranked 8 and enrolment rates at 9. Infrastructure scores are generally weaker than its average rankings with poorest scores found for quality of electricity supply (53) and overall infrastructure quality (45) in 2009-10 results. In addition, relatively weak scores are found for macroeconomic stability.

Efficiency Enhancers

Greatest improvement in ranking (initially 18, falling to 22 and improving to 11) is observed for Higher Education and Training where secondary enrolment ranked 2 and tertiary at 8; quality of maths and science education also scored in the top 10 in 2009-10. There is strong evidence of well-functioning efficient markets with top rankings relating to procedures and time required to start a business and also in relation to agricultural policy costs. Customs procedures are not burdensome, ranked 4. Costs of firing (measured in weeks' wages) rank the country in top position and a similar top ranking is evident for investor protection. Weakest performance in rankings for market efficiency are evident in the extent of local competitive intensity (53), the extent and effect of taxation (53), impact on business of rules on FDI (61), regulations governing hiring and firing (90), and the country's ability to attract and retain talent (84). Performance for technological readiness has ranked consistently in the high twenties while market size is predictably poor for this country, as an SOE.

Innovation and Sophistication

New Zealand's weakest performance is observed for this category and the gap in performance relative to the other two categories has widened over time. A drop from 22 to 27 is observed, caused by weaker outcomes for Business Sophistication. Local supplier quantity is problematic (ranked 83), the state of cluster development is weak (56) and local companies do not enjoy a broad value chain presence (53). While the ranking for Innovation has been maintained (ranked between 23 and 26), difficulties in improving on this outcome are evident in the availability of scientists and engineers (59) – despite strong ranking of the quality of scientific research institutions (at 14) - and in the role of government procurement of advanced technological products (57).

Table 4: Global Competitiveness Index and Components: New Zealand

	GCI	(A) Basic Requirements Rank (Score)	(B) Efficiency Enhancers Rank (Score)	(C) Innovation & Sophistication Rank (Score)
05-06	22	15 (5.66)	13 (5.24)	22 (4.75)
06-07	23	16 (5.65)	21 (5.15)	15 (5.11)
07-08	24	17 (5.53)	18 (5.10)	25 (4.42)
08-09	24	19 (5.58)	17 (5.07)	28 (4.26)
09-10	20	16 (5.58)	15 (5.11)	27 (4.37)
Weighting in GCI		20%	50%	30%

(A)	Basic Requirements	<i>Institutions</i>	<i>Infrastructure</i>	<i>Macro-stability</i>	<i>Health/Prim edn</i>
05-06	15 (5.66)	7 (5.47)	23 (5.07)	21 (5.17)	18 (6.93)
06-07	16 (5.65)	8 (5.65)	27 (4.88)	25 (5.12)	6 (6.93)
07-08	17 (5.53)	9 (5.80)	33 (4.52)	36 (5.36)	4 (6.45)
08-09	19 (5.58)	8 (5.81)	42 (4.37)	25 (5.72)	5 (6.42)
09-10	16 (5.58)	5 (6.03)	35 (4.64)	33 (5.24)	4 (6.43)

(B)	Efficiency Enhancers	<i>Higher Ed & Training</i>	<i>Gds mkt eff*</i>	<i>Lab mkt eff*</i>	<i>Fin Mkt soph*</i>	<i>Tech read</i>	<i>Mkt Size**</i>
05-06	13 (5.24)	18 (5.46)	10 (5.22)			19 (5.05)	
06-07	21 (5.15)	22 (5.33)	15 (5.17)			23 (4.94)	
07-08	18 (5.10)	12 (5.53)	9 (5.35)	9 (5.17)	4 (6.02)	23 (4.82)	59 (3.69)
08-09	17 (5.07)	15 (5.40)	17 (5.17)	10 (5.10)	3 (5.87)	22 (5.09)	60 (3.78)
09-10	25 (5.11)	11 (5.49)	8 (5.20)	11 (5.12)	3 (5.69)	23 (5.24)	59 (3.89)

*In 2005-2006 the method applied in assessing market efficiency included the markets goods, labour and finance together under one competitiveness pillar. In later years these were separated into separate pillars.

**This pillar was included as a pillar of competitiveness in an improvement to the underlying methodology in 2007-08.

(C)	Innovation & Sophistication	<i>Business Sophistication</i>	<i>Innovation</i>
05-06	22 (4.75)	22 (5.24)	23 (4.25)
06-07	25 (4.65)	26 (5.06)	25 (4.23)
07-08	25 (4.42)	29 (4.75)	25 (4.09)
08-09	28 (4.26)	37 (4.57)	26 (3.95)
09-10	27 (4.37)	34 (4.64)	23 (4.10)

Source: *Global Competitiveness Report*, various editions, World Economic Forum, Palgrave Macmillan.

Republic of Ireland

Rankings and scores for the Republic of Ireland's competitiveness pillars are listed in Table 5 with the breakdown for each category of Basic Requirements, Efficiency Enhancers and Innovation and Sophistication Factors presented in panels A, B and C in the Table.

Basic Requirements

Performance across three of the four pillars here has declined, the greatest the 50-rank drop to 65 for macroeconomic stability (with a ranking of 125 for government deficit, and 87 for both government debt and the national savings rate). Although much of this deterioration is explained by the international recession, and the Republic of Ireland's unfavourable response to it, the ranking for Infrastructure displays a drop of 20 positions. Overall infrastructure ranked 65 (with road quality ranked 59) is problematic and at odds with the average rankings of other pillars. Institutions declined in ranking from 14 to 19 over the period and in latest results, the most challenging elements include the perceived burden of government regulation (ranked 74) and wastefulness of government expenditure (63). Improvement in the Health and primary education pillar is in evidence being driven in recent results by strong scores for the quality of primary education (9), life expectancy (15) and infant mortality (15).

Efficiency Enhancers

The rankings for the Higher Education and Training pillar remained relatively consistent and strong performance in most recent results were observed for secondary enrolment (6) the quality of the educational system (8), the extent of staff training (15) and the quality of management schools (19). Market efficiency declined most significantly, if unsurprisingly, in financial markets (from 7 to 45 in 2009-10) while more modest declines (of 6 – 7 ranks in the last 2 years) in goods and labour market efficiencies were measured. Some of the rankings lost in Technological Readiness in the period from 2007-2009 has been regained and the current ranking of 21 includes a top score (ranked 1) for the role of FDI in bringing new technology to local subsidiaries with top 20 rankings for use of personal computers and internet users. The impact of the limited local market acts as an impediment to productivity growth, a finding shared with other SOEs.

Innovation and Sophistication

The Republic of Ireland's ranking in this category has remained in the top 20, with the exception of the mid-sample 2007-08 ranking of 22. For all but that same time period, rankings for Business Sophistication were between 2 and 4 ranks higher than for Innovation. Companies' competitive advantage lies relatively in favour of unique products and processes (ranked 18) with similar rankings for the sophistication of production processes. Weaknesses in control of international distribution (ranked 53) and limited availability of local suppliers (39) would need to be addressed to improve rankings further. Local availability of scientists and engineers and the quality of research institutions (ranked 12 and 16 respectively) are strengths evident in the innovation ranking. However, the capacity for innovation is more limited (rank 30) and the role played by government in procuring technologically advanced products is weak (rank 59).

Table 5: Global Competitiveness Index and Components: Republic of Ireland

	GCI	(A) Basic Requirements Rank (Score)	(B) Efficiency Enhancers Rank (Score)	(C) Innovation & Sophistication Rank (Score)
05-06	21	22 (5.52)	14 (5.23)	19 (4.91)
06-07	21	23 (5.46)	18 (5.21)	19 (4.96)
07-08	22	27 (5.31)	19 (5.05)	22 (4.80)
08-09	22	32 (5.24)	19 (5.05)	20 (4.72)
09-10	25	37 (5.06)	22 (4.87)	20 (4.63)
<i>Weighting in GCI</i>		<i>20%</i>	<i>50%</i>	<i>30%</i>

(A)	Basic Requirements	<i>Institutions</i>	<i>Infrastructure</i>	<i>Macro-stability</i>	<i>Health/Prim edn</i>
05-06	22 (5.52)	14 (5.27)	32 (4.58)	15 (5.31)	21 (6.93)
06-07	23 (5.46)	17 (5.15)	31 (4.61)	20 (5.27)	24 (6.78)
07-08	27 (5.31)	18 (5.25)	49 (4.03)	21 (5.69)	16 (6.28)
08-09	32 (5.24)	17 (5.39)	53 (3.95)	47 (5.33)	14 (6.28)
09-10	37 (5.06)	19 (5.21)	52 (4.19)	65 (4.63)	10 (6.23)

(B)	Efficiency Enhancers	<i>Higher Ed & Training</i>	<i>Gds mkt eff*</i>	<i>Lab mkt eff*</i>	<i>Fin Mkt soph*</i>	<i>Tech read</i>	<i>Mkt Size**</i>
05-06	14 (5.23)	21 (5.40)	13 (5.08)			13 (5.20)	
06-07	18 (5.21)	16 (5.52)	13 (5.22)			24 (4.89)	
07-08	19 (5.05)	21 (5.26)	4 (5.41)	19 (4.87)	5 (5.91)	25 (4.65)	46 (4.17)
08-09	19 (5.05)	20 (5.18)	9 (5.30)	15 (4.95)	7 (5.68)	24 (4.98)	48 (4.22)
09-10	22 (4.87)	20 (5.12)	15 (5.09)	22 (4.86)	45 (4.60)	21 (5.27)	52 (4.26)

*In 2005-2006 the method applied in assessing market efficiency included the markets goods, labour and finance together under one competitiveness pillar. In later years these were separated into separate pillars.

**This pillar was included as a pillar of competitiveness in an improvement to the underlying methodology in 2007-08.

(C)	Innovation & Sophistication	<i>Business Sophistication</i>	<i>Innovation</i>
05-06	19 (4.91)	15 (5.39)	19 (4.44)
06-07	19 (4.96)	16 (5.39)	20 (4.54)
07-08	22 (4.80)	22 (5.07)	19 (4.54)
08-09	20 (4.72)	19 (5.05)	21 (4.39)
09-10	20 (4.63)	18 (4.97)	22 (4.29)

Source: Global Competitiveness Report, annual editions 2005, 2006, 2007, 2008, 2009, World Economic Forum, Palgrave Macmillan.

2.3 Discussion:

Long term strong productivity performance and improvement depends on a complex array of determinants, one approach to which is organised in the Global Competitiveness Index. The breakdown of the concept of competitiveness according to the three broad themes which are disaggregated further in turn allows identification of those factors most constraining economic development. The listings of relative strengths and weaknesses can serve to provide a platform for dialogue between government, business and the wider society to catalyse competitiveness-improving reforms focused ultimately on boosting prosperity and living standards. Decisions on prioritisation of such reforms follow no unique trajectory, however. What the competitiveness framework underlying the GCI does offer is an approach within which to consider direct and indirect impacts of reforms in the process of selection of action and implementation strategies for both business and policy stakeholders.

The depiction of competitiveness offered by competitiveness profiling outlined in Tables 3-5 is predicated on a stages-of-development approach. While each of our focus economies is characterised within the 'innovation-driven' stage of development quite varying rankings and scores are observed as no individual economy's competitiveness is explained solely by its innovation performance since that, in itself, is dependent on and guided by other facets of the economy relevant from the macroeconomic level right down to individual businesses. The logic of the approach is that competitiveness in all developed economies is determined by sets of elements under the three categories – but to varying degrees - and the triggers for improving current productivity/competitiveness performance depend increasingly on innovation and sophistication factors for most developed economies.

The reliability that may be placed in the rankings in terms of their link to economic prosperity and productivity arises from the fact that the measures generated by the GCI have been found to relate (statistically and econometrically) to GDP per capita for the sample of over 130 countries. Recent analysis of data from the Global Competitiveness rankings by Porter et al (2008) found that **over 85% of variation across countries' levels of GDP per capita were explained by the elements of the twelve competitiveness pillars**, quite remarkable given the variation in levels of economic development of countries included in the analysis.⁵

An interesting and notable outcome of relevance in our focussed SOE context was that for countries at higher levels of development, those elements of their microeconomic competitiveness environment⁶ and the national business environment⁷ mattered most for competitiveness. Of relatively less importance were measures related to the Social

⁵ While it was announced in the 2008-2009 *Global Competitiveness Report* that Porter's redevelopment of the Global Competitiveness Index published in that Report would form the basis for each subsequent report, this was not the case and the previously used methodology was applied once more for 2009-2010.

⁶ Encompassing company operations and strategy which is defined to include firms' strategies and efficiency, organizational practices and internationalization of firms.

⁷ Including elements representing Factor Conditions, Demand Conditions, Context for Strategy and Rivalry and Supporting/related industries – Porter's 'Diamond' model.

infrastructure and political institutions (including measures of education, health, political institutions' quality and rule of law) followed, in order of importance by Macroeconomic policy (fiscal and monetary). Unfortunately the categorisation used by Porter (2008) does not correspond exactly to the 'pillars of competitiveness' defined above. However, the underlying data used in estimation was that used in compiling the GCI and we can conclude with confidence that comparison is reasonable. The underlying logic for the revised methodology (proposed by Porter, 2008) is that it is more conducive to identification of priorities for productivity improvement at specific policy level. This recognises that many factors matter for productivity and competitiveness and economies "often get bogged down in their efforts to improve competitiveness by tackling too many individual issues in parallel. The challenge is to identify those areas where action can unlock higher productivity at a given point in time".⁸

Focusing on innovation in particular, for both Singapore and New Zealand their areas of weakest performance are evident in the Innovation and Sophistication category. Individual elements for the two pillars feeding into this category identify areas for improvement for each economy respectively and point to specific functions in terms of either public policy and/or business strategy. In the case of Singapore, despite recent improvements in its rankings in Business Sophistication, weaknesses remain in local supplier quantity, and quality, and for control of international distribution channels. The foregoing weaknesses impinge on its reported Business Sophistication score and priorities might be identified in addressing these areas. For New Zealand its Business Sophistication ranking has declined (explaining the decline in its overall ranking for Innovation and Sophistication) with specific areas of most concern including local supplier quantity, state of cluster development and nature of competitive advantage (focussed more on low cost and resource-based rather than unique products or processes). In the case of RoI, while its Innovation and Sophistication ranking has remained relatively constant, relative weaknesses relate to local supplier quantity, control of international distribution and state of cluster development.⁹

The SOE status of these economies would explain general weakness in terms of the number of local suppliers and there may be some merit in arguing for a recalibration of the GCI to take account of particular features associated with SOEs. However, this would reduce the comparability across countries of the index and omit a factor which has theoretical and empirical explanatory power for productivity and competitiveness in the broader sample. Of more relevance from an SOE perspective would be to examine, for example, the factors underlying weak supplier quality or the nature of competitive advantage pointing to targets for both public and business policy.

⁸ Porter et al, 2008: 53.

⁹ Arguably Ireland's most pressing competitiveness weaknesses reside in its declining rankings for Basic Requirements since many have considerable knock-on effects for both efficiency and innovation capabilities. However, the extent to which Ireland has managed to compete internationally, despite weaknesses here points to the idiosyncratic nature of and evolution of competitiveness. Notwithstanding Ireland's recent strong economic performance, of 33 innovation-driven economies, only Italy is ranked lower for its Infrastructure and from an SOE perspective it is difficult to argue that this should not be an area of particular focus for improvement. An alternative perspective would also appear valid – that to improve rankings would require focus on Efficiency Enhancers since these are more significant determinants of competitiveness (reflected in their relatively higher weighting in the index).

Our focus on SOE status and its impact on innovation and innovative capacity remain the focus of the following section.

3. Innovation Capacity Profile - SOEs

Innovative capacity is a core determinant of competitiveness particularly for advanced modern economies, since they are likely to have limited ability to generate increased output from further investments in capital (the efficiency-driven stage). Taking advantage of improvements in modelling innovative capacity in this section we present the outcomes of three alternative and complementary approaches to the determinants of innovative capacity for 23 modern developed economies from 1993-2005. This allows us to identify the most significant - statistically and economically - determinants of innovation at the national level, with our specific focus on small open economies.

Empirically, the variation in the ability of countries to produce new-to-world technologies, that are defined here as patents, is striking. Some countries consistently outperform others by a wide margin. For example, Canada, the US, Finland, Switzerland and Japan produce well over 100 patents per year per million of population (in 2008), while most advanced economies average approximately 60 patents per million and still another group including Spain, Portugal, New Zealand and Italy may all be considered to 'underperform' with less than 25 patents per million.

Such variation in patent outcomes is not explained by larger economies performing better, or smaller nimbler economies generating better results. As Furman *et al.* (2002) point out **there is a strong patenting bias in those countries which have a history of patents production** such the US and Switzerland due to path dependency and the importance of the history of resource commitments. Some other 'new innovative countries' rates of growth in patents per million has been nothing short of phenomenal - Singapore, for example, has an average annual patent growth rate of 30% between 1981 and 2008, going from just over 1 patent per million in 1981 to 84 in 2008.

Such performance begs analysis and raises the question for us as to whether smaller economies generally are supported or hindered by their relatively low scale, or low critical mass in economic terms, in achieving innovative success, measured in terms of patents.

The issue considered here is **whether the drivers of Innovative Capacity vary across advanced economies when categorised by their SOE status**. Thus, this element of our analysis addresses one possible heterogeneity that may exist. We examine the extent to which the same basic factors drive a nation's Innovative Capacity as previously found in the literature and question whether or not the mix of policy choices for an SOE are significantly different from other economies. Specifically we investigate whether SOEs perform differently in terms of their innovative output (patenting activity) compared to their large economy peers when the same basic policy mix is applied.

This question addresses a gap in the literature and, therefore, it is necessary to assess the relative performance of SOEs. While some literature on innovative capacity

examines specific SOEs, such as New Zealand in Marsh (2000), it tends to concentrate on an individual industry without adopting a broader international perspective provided here, grounded in the National Innovative Capacity approach.

3.1 National Innovative Capacity Framework

According to Furman *et al.* (2002: 899) an economy's innovative capacity represents "the ability ... to produce and commercialize a flow of innovative technology over the long term". We agree that Innovative Capacity should be viewed differently to pure science and technology advances – to include application of new management models, new business models, product or service innovation, technological innovation and operational innovation - as our interest is in *economically viable applications*, i.e. the outcome of market decisions on innovations, whatever their source. The discovery of a new technology (or significant facts/information) is considered to be independent of its benefit to an economy unless it can be harnessed *domestically* through having the structures and resources available to exploit its value before the knowledge becomes diffused and may be exploited elsewhere. However, limited by availability of data that would include successful commercialisation of innovations we stick with an accepted approach in this literature of focusing on available data relating to patents as a measure of innovative activity.¹⁰

The National Innovative Capacity framework (NIC)¹¹ is presented in Figure 2. Many studies (including Gans and Stern, 2003; Gans and Hayes, 2008) have followed this approach finding evidence to support the contention that the intensity to which countries innovate varies based on a set of variables relating to the following elements;

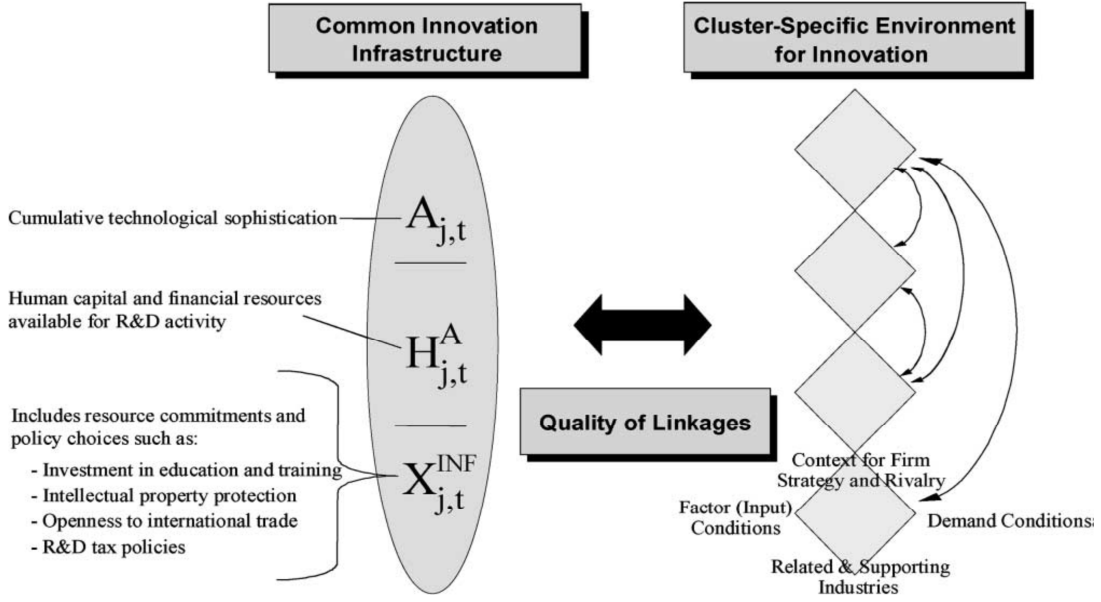
- *The Common Innovative Infrastructure*: this element of the framework accounts for features of an economy's innovation infrastructure that confer no particular advantage on any sector (or cluster) yet provide support for innovation activities generally across the economy.
- *The Cluster Specific Environment*; This aspect of the innovative capacity of an economy makes reference to microeconomic theory (following Porter, 1990), specifically the fact that while wider policy-related issues facilitate innovation but it is ultimately firms that create new technologies. As there are few national or international statistics pertaining directly to the extent of cluster activity this research requires the development of a proxy measure.¹²
- *The Quality of Linkages* takes account of factors that reinforce the two previous points by creating connections from the micro to the macro level. For instance even firms within a well developed cluster will not be able to produce economically viable new-to-world technologies unless they have access to a pool of scientists and engineers and access to basic research and, in some cases, perhaps access to advice from local universities.

¹⁰ For a fuller discussion of the pitfalls associated with the use of international patents granted as a proxy for innovative output see Pavitt (1982), Griliches (1984), Trajtenberg (1990) and Furman *et al.* (2002).

¹¹ The antecedents on which the NIC framework builds includes research from ideas-driven growth theory outlined in the National Ideas Production Function of Romer (1990) and Jones (1995), on microeconomics-based models of national competitive advantage and industrial clusters, developed by Porter (1990) and on research on National Innovation Systems proposed in Nelson (1993).

¹² For more on the challenges of applying a cluster approach see Doyle and Fanning, (2007).

Figure 2: National Innovative Capacity Framework



Source: Furman *et al.* (2002: 906).

Such an approach facilitates the identification of a set of economic factors that drive patenting activity, or intensity, and also allows for a policy-centred focus on how to best consider the long-term choices that impinge on innovation capacity.

3.2 Empirical Analysis

Our empirical analyses enabled a dissection of the drivers of National Innovative Capacity across our sample of 23 advanced economies over the period 1993 to 2005 using annual data and with specific focus on the results for our sample of SOEs.¹³ No standard method is offered in the literature to define an SOE, hence for our purposes we define a country as an SOE when its GDP makes up less than 2% of the 23 countries' aggregate GDP and when its exports plus imports, relative to its GDP, is equal to or greater than 70%, (which is within half a standard deviation of the mean of 100%).

Our main specification takes the following form:

$$LA_{j,t} = \alpha + \delta_{YEAR} YEAR_t + \delta_{INF} L X_{j,t}^{INF} + \delta_{CLUS} L Y_{j,t}^{CLUS} + \delta_{LINK} L Z_{j,t}^{LINK} + \lambda L H_{j,t}^A + \varphi L A_{j,t}^\varphi + \epsilon_{j,t}$$

Conditional on a given level of R&D inputs, defined as labour and capital devoted to introducing new ideas in the economy, (H^A), variation in the production of innovation i.e.

¹³ Our initial sample included 30 OECD countries plus Singapore but Portugal, Turkey, Iceland and Greece were omitted due to lack of availability of data, Poland and Mexico due to extremely low levels of national patenting activity and Luxembourg due to its idiosyncratic features, given its size etc..

the flow of new-to-the-world technologies from each country (A) reflects R&D productivity differences across countries or over time. The variable X^{INF} refers to the level of general resource commitments and policy choices that constitute the Common Innovation Infrastructure, Y^{CLUS} refers to the particular environment for innovation in a country's industrial clusters, and Z^{LINK} captures the strength of linkages between the common infrastructure and the nation's various clusters.¹⁴ A^φ represents the total stock of knowledge held by an economy at a given point in time relevant to drive future ideas production.

Our dependent variable is the number of international patents, defined as “the number of patents granted to inventors from a particular country other than United States by the USPTO in a given year. For the United States, PATENTS is equal to the number of patents granted to corporate or government establishments (this excludes individual inventors)” (Furman et al. 2002: 909).¹⁵ As $A_{j,t}$, measured by the level of international patenting, is only observed with delay, our empirical work imposes a 3-year lag between the measures of innovative capacity and the observed realization of innovative output.¹⁶

Our independent variables include R&D Funding, R&D Employment levels, Economic Development, Openness to International Trade, Intellectual Property Protection, % of R&D conducted in Universities and % of R&D conducted in Private Enterprise.¹⁷ The models were estimated as a panel (eight in total were estimated), and given this technique the results are estimated as an average for the sampled countries, rather than on an individual basis. Results of the empirical estimations for the full sample of countries and the SOEs are reported in Table 6. These results are arranged according to the Ideas Production Function, Common Innovative Infrastructure and National Innovative Capacity specifications.

Test of Parameter Stability

All estimations were tested using Chow Tests of Parameter Stability to assess if there is a significant difference between the determinants of National Innovative Capacity in SOEs and the economies in the full sample of advanced economies. All models indicated no statistically significant change in the relationship between patent production and variables that were found to contribute to it, when estimated for SOEs or the full sample of economies. Based on these findings we conclude that innovation in SOEs is driven by the same set of factors as other economy structures and SOE status confers neither advantage nor disadvantage for patenting activities.

¹⁴ The analysis is organized around a log–log specification, except for qualitative variables and variables expressed as a percentage. The estimates, thus, have a natural interpretation in terms of elasticities, are less sensitive to outliers, and are consistent with the majority of prior work in this area including Jones (1998), Furman et al. (2002), Gans and Stern (2003), Gans and Hayes (2008).

¹⁵ Any asymmetry this may cause between US and non-US patents does not affect our results as we include a US dummy variable in our regressions, in keeping with the previous literature.

¹⁶ Employing alternative lag structures do not significantly alter our results.

¹⁷ Our data sources are OECD, USPTO, IMF World Economic Outlook, Economic Freedom of the World Index, and World Bank Education Statistics.

However, some differences in the impact of variables on our SOE and full samples of advanced economies were found in our analyses of the determinants of patent production.

3.4 National Patent Stock and Level of Economic Development

The level of economic development was proxied in our analyses by *GDP* and *GDP per Capita*. When these variables were included and patent stock excluded, coefficients on GDP or GDP/capita were not statistically significant (models 1 and 2). Our analysis confirms a general finding that a country's *Patent Stock* is major factor in determining its current and future patent output. For our sample, a 10% increase in *Patent Stock* resulted in approximately a 2% increase in patent production consistent across the entire sample, and for SOEs. We know also that examples such as Singapore illustrate that it is possible to buck the trend and rapidly accumulate patents even from a low historical level.

When *Patent Stock* was included (model 3) we also included the level of development at the beginning of the sample (GDP 1993) to provide a base-line level of development for each country. For the whole sample of advanced economies 10% difference in a country's level of development in 1993 resulted in a 3.5% increase in patenting. However, for SOEs this variable is statistically insignificant.

R&D Activity

In previous studies both *R&D Expenditure* and *Personnel Employed in R&D* were statistically significant determinants of patent production. In this sample using a more recent data set we find that when both are included the explanatory power of the numbers employed in R&D becomes insignificant although expenditure retains its significance.

In fact, R&D spending is found to be the most significant determining factor and to have very similar results for SOEs and the full sample of countries. A 10% increase in spending (models 3) is found to result in a 4.8% to 5.5% increase in patent production for the full sample with relatively larger impacts of between 6.7% and 7.5% for SOEs.

Property Rights Protection and Openness

The two variables *Legal Structure and Security of Property Rights* and the *Openness* of an economy to international trade are based on average survey response by executives on a 1-10 scale from the Economic Freedom of the World Index. Both variables are significant explanatory factors with a 10% (i.e. a one-point) increase in the perceived level of Property Protection resulting in approximately a 1% increase in patents for the full sample and over 3% for our SOEs. For *Openness*, we find a 50% greater impact on patent production in SOE's relative to the average sample at over 2%, given the estimate of 1.4% for the full sample.

Further Potential Determinants - Innovative Activity

Our control variables for the Cluster Specific Environment were insignificant. Our measure of the share of R&D funded by the private sector focuses on the general importance of innovation-based competition across all clusters in an economy. We also calculated a measure of the degree of technological focus by country (Specialisation) to proxy the intensity of innovation-based competition in a nation's 'clusters' of Chemicals, Electronics and Mechanical sectors.

Our measure of the quality of linkages addressed Higher education institutions and their role in R&D by including the measure of universities' share of R&D in total national R&D. This was found to be insignificant for our sample, supporting research elsewhere¹⁸ focusing on the European context, in particular.

A negative constant term¹⁹ was also found in all of the regressions we ran, which implies that a large amount of work must be undertaken on a nation's Innovative Capacity before it begins to produce economically viable innovations and, therefore, patents. This lag reiterates the point of earlier studies²⁰ that patience is a requirement to achieve an increased level of Innovative Capacity. Furthermore, we identify that the effort to achieve the first patent is consistently larger for SOE's, approximately 50% greater than for the average sample – given relatively larger absolute coefficients on the constant term.

3.5 Discussion

We find that application of the National Innovative Capacity framework generates robust results and the percentage of variation in patenting activity explained by this approach is over 92%, which is higher than for the Ideas Production Function and Common Innovative Infrastructure methods.

Our analyses reveal that SOEs use the same basic principles as the 'average' advanced economy to generate innovative activity based on data from 1993-2008. The important caveat applies that, following literature in this area, we use patents for our measure of innovative activity which is arguably a crude measure of innovation of economic relevance that generates more unique products and processes for which consumers are willing to pay and/or that generate broad societal benefits by, for example, increasing the efficiency of delivery of service. However, in the absence of a well-articulated and agreed alternative that would focus only on such economically relevant measures of innovating activity, encompassing creativity and resourcefulness and science and technology inputs, we limit ourselves to patents generated by innovation inputs.

We find that R&D expenditure was the most economically (and statistically) significant determinant of innovative activity, measured as patents, but the percentage increase in expenditure required to increase patents is less than 1:1, again, this investment offers us little by way of information on the market impact or commercialisation of those patents. As outlined in Report 2 in this Series, while patent ownership does not guarantee

¹⁸ Including Roper et al (2008) and Roper et al (2009).

¹⁹ Similar to the finding in Furman, Porter and Stern (2002). To conserve space these statistics are not reported here but can be found in Doyle, O'Connor and Kuah (2009).

²⁰ Such as Gans and Stern (2003).

successful commercialization, it is a necessary condition for exploiting new technologies and conquering high technology markets.

Our results indicated that the coefficient *Personnel Employed in R&D* was consistently insignificant and reduced in magnitude once *R&D Expenditure* was included, in contrast to other research where both human and financial capital were found to be significant in the production of patents. One reason is this study's increased number of countries studied that could mean there has been a change or structural break in the way patents are produced in more recent years, requiring ever more sophisticated capital for each extra patent produced and making the number of researchers less important than heretofore. One possible support for this idea is that as time goes on the *Year Fixed Effects* decline, implying that it becomes more difficult to innovate successfully each year. This gap may well be bridged more easily by more advanced technology as higher-end researchers are in short and inelastic supply. Another possibility is that the variable is too broadly defined here and if it only included researchers and engineers, and excluded support staff, it may again become significant. This is an area that requires further study before public or business policy implications were to be drawn.

While we find that SOEs do not require a particularly different mix of ingredients to increase Innovative Capacity, in a number of cases, the specific importance of variables was greater for SOEs than our larger sample. Further research in this area is required to support these ideas, such as using an extended data set to include a broader range of countries as well as more investigations around the definition of SOE.

In the next section of this report we examine in more detail the productivity and innovation experiences of our SOEs. Through a series of semi-structured interviews we explore with a range of business, government and relevant institutional players, in each economy separately, the context and institutional supports relevant for competitiveness, innovation and productivity.

Table 6: Determinants of Patent Output, 1993-2008: Alternative Specifications

	Determinants of New to World Technologies (using GDP or GDP/POP as Knowledge Stock)				Determinants of New to World Technologies (using GDP or GDP/POP as Knowledge Stock)				Determinants of New to World Technologies (using Patent Stock as Knowledge Stock)			
<i>Coefficients are followed by P-values below.</i>	Ideas Production Function				Common Innovative Infrastructure				Common Innovative Infrastructure	National Innovative Capacity		
	1 Full	1 SOE	1A Full	1B SOE	2 Full	2 SOE	2A Full	2B SOE	3 Full	3 SOE	3A Full	3B SOE
QUALITY OF COMMON INFRASTRUCTURE:												
GDP	0.47 0.57	0.05 0.62			0.12 0.15	0.22 0.05						
GDP PER CAPITA			0.02 0.85	0.10 0.33			0.05 0.57	0.22 0.03				
Population	0.68 0.00	0.27 0.36			0.29 0.03	0.08 0.74						
Patent Stock									0.19 0.00	0.210 .00	0.22 0.00	0.25 0.00
R&D Personnel	0.56 0.00	1.35 0.00	0.79 0.00	0.99 0.00	0.13 0.10	0.25 0.23	0.16 0.05	0.28 -0.15	0.09 0.28	-0.01 0.93	0.10 0.22	0.13 0.41
R&D Expenditure					0.70 0.00	0.71 0.00	0.84 0.00	0.72 0.00	0.55 0.00	0.750 .00	0.48 0.00	0.67 0.00
Expenditure on 2 nd & 3 rd level education as % GDP					-0.01 0.78	-0.13 0.75	0.10 0.00	-0.01 0.73	-0.03 0.38	-0.03 0.70	0.03 0.31	-0.02 0.55
Legal Structure and Security of Property Rights					0.13 0.00	0.25 0.00	0.08 0.09	0.27 0.00	0.10 0.01	0.32 0.00	0.09 0.03	0.34 0.00
Openness					0.19 0.00	0.23 0.00	0.14 0.00	0.23 0.00	0.14 0.00	0.220 .00	0.14 0.00	0.23 0.00
CLUSTER SPECIFIC INNOVATION ENVIRONMENT:												
Private R&D							0.000 9 0.833	0.00 0.62			0.00 0.08	0.01 0.72
Specialisation							-0.03 0.13	-0.07 0.01			-0.03 0.28	-0.07 0.01
QUALITY OF LINKAGES:												
UNI R&D											-0.01 0.01	0.01 0.58
GDP 1993									0.34 0.00	0.08 0.47	0.33 0.00	-0.09 0.34
R ²	0.751	0.688	0.835	0.649	0.878	0.887	0.902	0.906	0.920	0.929	0.927	0.951

4. Business and Policy Environments Impacting SOE Productivity, Innovation and Competitiveness

This section of the report outlines the country analyses resulting from field work conducted across our three selected SOEs. Each country report is a separate element of this section, beginning with New Zealand, moving to Singapore and finishing with the Republic of Ireland, and is organized in two sub-sections per country. We concisely present case study findings in three focal sectors for each country: food processing, advanced manufacturing and materials, and advanced services sector. First, a brief 'macro-environment' overview, including key information on population, economic structure, and recent trends is offered. Second, key aspects related to the development, challenges, corporate strategies, and policy initiatives of three key study sectors - food processing, advanced manufacturing and materials, and the advanced services sector - are reviewed. Summary observations and key insights for policy arising from our fieldwork are presented in Section 5 of this Report.

Section 4.1 draws on a series of field interviews conducted in New Zealand in November 2009. Twenty-two interviews were conducted: 6 with governmental officials from ministries and research foundations, 9 with private sector companies, 5 with universities or crown research institutes, and 2 with non-profit or business organizations. In total, we met with 31 people. The interviews were conducted in the Auckland region, although our interviews included officials based in Wellington (in person or by phone and video link).

Section 4.2 draws on a series of field interviews conducted in Singapore during the months of September and November 2009. Seventeen interviews were conducted: 6 with ministries and statutory boards involved in economic development, international trade and business support; 8 with companies in emerging sectors, financial services, chemicals and food processing; a manager of Science Park II; and finally, informal discussions with an eminent professor and another with a Member of Parliament (MP). In total, we met with 25 participants.

Section 4.3 reports on a series of field interviews conducted in the Republic of Ireland between October and December 2009. Seventeen interviews were conducted: 7 with private-sector companies across our sectors of interest, 1 each with a Manager of a Research Centre, and an industry association chief, 2 with government agencies targeting business support 2 with national policy advisory agency bodies and 1 with a regional economic development agency. We spoke to 23 participants in total.

As a complement to the information gleaned from interviews, available data, reports, and other secondary materials were widely consulted, as referred to below.

4.1 Business & Policy Environment - New Zealand

New Zealand has experienced consistent population growth in recent decades. From under 2 million in 1950, the population surpassed 3 million in 1974, reaching 4 million in 2003 with latest estimates (September 2009) at 4.33 million.^{21 22} Net in-migration has been the major source of growth with New Zealand ranked 4th among reporting OECD countries in its share of foreign-born population (21.2% in 2006).

National economic structure has shifted increasingly towards services, with retention of a significant agricultural base. As in other developed countries, the share of value-added contributed by industry has declined, from 25.4% in 1978 to 19.1% in 2003: for agriculture (including forestry and fishing) the corresponding decline has been from 10% to 6.5%. As agriculture contributed just 1.2 % of value added averaged across all OECD economies, New Zealand clearly remains relatively highly dependent on agriculture. Service industries comprise the largest sector of the economy, accounting for about two-thirds of GDP. Key service industries include financial services, transport, tourism, and communications. Following slow services growth in the 1990s, it grew strongly in the 2000-2005 period, with above average growth (compared to GDP) in services through to 2008.²³ The recent global economic downturn has led to some cyclical weakening in several services, including tourism and financial services.

In the 1950s, New Zealand had among the highest levels of GDP per capita in world, but by 2007 the country fell to 22nd among OECD countries on this indicator²⁴ : while labour utilization has increased, productivity growth remains well below the OECD average. Analysts suggest that one of the factors contributing to this is New Zealand's low gross expenditure on R&D, which at 1.16% of GDP (2005) is about half the average level for the OECD (2.23% in 2005).²⁵

The recent OECD innovation review highlights for New Zealand economic reforms undertaken since the late 1980s noting a number of innovation system strengths. These include positive basic conditions for entrepreneurship and innovation, competent public administration, public research institutional capabilities, competitive nature-resource based sectors, and pockets of excellence in software, creative industries and new sectors. Weaknesses identified include physical infrastructure, broadband Internet availability and cost, weak business R&D, barriers to business growth including distance to markets, lack of public support for innovation-related investments, the "lifestyle" orientation of some entrepreneurs, and lack of management skills and limitations in technology diffusion. Overreliance on maintaining "policy principles" at the expense of "efficacious

²¹ OECD Factbook 2009: Economic, Environmental and Social Statistics. OECD, Paris. 2003 is the latest year of data reported by the OECD for New Zealand in this compilation.

²² Statistics New Zealand, National Population Estimates: September 2009 quarter, http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationEstimate_s_HOTPSep09qtr.aspx (accessed January 2, 2010).

²³ The Treasury, New Zealand Economic and Financial Overview 2009. Wellington, May 5, 2009.

²⁴ P. Mawson, *Measuring Economic Growth in New Zealand*, Working Paper 02/13, New Zealand Treasury, Wellington, September 2002.

²⁵ OECD, *OCED Reviews of Innovation Policy*: New Zealand, Paris, 2007.

implementation”, resulting in high transaction costs through the strict separation of customer and contractor functions in public R&D funding was targeted for criticism.²⁶

Food Processing

The primary agricultural and horticultural sector contributes about 5% to New Zealand’s GDP, with the tightly-linked food and beverage manufacturing (or “food processing”) sector contributing a further 2.9% of GDP. Related GDP contributions are made by downstream transportation, retail, and other activities linked to agriculture and food processing. New Zealand’s leading products include dairy produce, beef, lamb, fruit (including apples and kiwifruit), wine, processed vegetables, seeds and agricultural services. Notably 50% of New Zealand’s export earnings are derived from agricultural production.²⁷ About 337,000 people - or 10% of persons employed - work in the agricultural and food value chain, including primary agriculture, food processing, wholesaling, and retail and food service. Of these, about nearly 74,000 (22%) are employed in food processing.²⁸

The sector has changed significantly over the past four decades with a shift from predominantly supplying the UK (prior to EU entry in 1973) to exporting globally including to the USA, Japan, China, the EU and Australia. This required new production, marketing and distribution strategies to respond to evolving and varied customer needs. 1984 saw a landmark change when producer subsidies to agriculture were eliminated. New Zealand is regarded as having one of the world’s least subsidized and most open agricultural markets. In 2008, agricultural subsidies were about 1 percent of the value of agricultural production, comprised mainly of public support for scientific research, compared with subsidies of 25% and 7% respectively in the EU and US.²⁹

Anticipated challenges facing the sector include reorganizing a domestic co-operative-based industry structure to compete internationally on a larger scale, enhancing productivity and innovation, and dealing with issues of sustainability, food security and bio-safety, animal welfare, water availability and climate change. Long-term demand for New Zealand agricultural and food exports is expected to expand, especially from emerging Asian economies, notwithstanding the recession fuelled impact on demand. International commodity prices have fallen - particularly for dairy products, although partly offset by exchange rate changes other competitors have emerged (for example, in the production of kiwi fruit), and domestic producers and companies face increasing difficulties in securing credit.³⁰ To face these challenges, the agricultural and food-sector can draw on well-developed capabilities for productivity-improvement, innovation and product development. The government invests more than NZ\$100 million (£45 million) a year in agricultural

²⁶ OECD 2007, op.cit.

²⁷ The Treasury, op. cit, 2009.

²⁸ Food and Beverage Skills Working Group, *Skills Action Plan for the Food and Beverage Sector*. Food and Beverage Taskforce, Department of Labour. Wellington, July 2006.

²⁹ OECD, *Agricultural Policies in OECD Countries: Monitoring and Evaluation*. Paris, 2009.

³⁰ Ministry of Agriculture and Forestry, *Briefing for Incoming Ministers*. Wellington, November 2008.

research, while the private sector invests about NZ\$174 million (£79.6 million) in R&D in the primary and food processing sectors.³¹

Fonterra is the largest agricultural and food processing business in New Zealand. The group is a co-operative, formed in 2001 with the merger of two cooperatives and New Zealand's Dairy Board. It is currently owned by more than 10,500 dairy farmers, although there have been intense discussions in recent years about restructuring the company to allow part of it to be publicly listed. The group is not only New Zealand's largest exporter, but also the world's leading exporter of dairy products, accounting for more than one third of global dairy trade, with some 15,600 employees, sales in over 140 countries, and annual revenues of NZ\$16 billion (£7.3 billion).³² Fonterra is a multi-national with subsidiaries, joint ventures, brands, and production facilities in multiple locations including New Zealand, Australia, Asia (including China), the USA, Europe, Latin America.

Our interview with Fonterra focused on its strategies for innovation and productivity improvement. The group's strategic emphasis is on innovation, especially in developing new, higher-value ingredients, processes and products. Examples include: new technology for cheese making which has reduced the manufacturing time of C-21 Mozzarella cheese from 8 months to 3 months; premium yoghurt texture and flavour bases; and enhanced protein-based dairy ingredients for functional foods, including sports and medical foods. Fonterra operates technical centres in Palmerston North, New Zealand, Melbourne, Australia, Chicago, USA, and Hamburg, Germany. The three international centres undertake technical support; the group's main R&D effort remains concentrated in Palmerston North, where 300 of Fonterra's 500 R&D employees are located.³³ Its R&D centre is part of a group of related facilities in Palmerston North, including a campus of Massey University, three agricultural-related Crown Research Institutes, and other agricultural research associations and businesses. Anchored by Fonterra, more than NZ\$200 million (£91.5 million) is invested annually in R&D, or about 10% of all New Zealand's R&D expenditures, making Palmerston North a leading global centre for agricultural and food R&D and innovation.³⁴ A focus of Fonterra's research in Palmerston North is to develop long-term platform technologies, including underpinning the food chemistry and physics, microbiology, sensory characteristics, and nutritional aspects of potential new products and processes. It collaborates with numerous external partners in developing long-term platform technologies: the group has research linkages with all major universities in New Zealand, with about 30 other universities around the world, and has made venture capital investments including in a US biosciences company.

Fonterra participates in Food Innovation a new programme founded in 2009 by six leading food R&D organizations to market New Zealand food R&D expertise globally and to attract other global companies to undertake food research domestically.³⁵ While Fonterra

³¹ Statistics New Zealand, *Research and Development Survey: 2008*. Wellington, April 2008.

³² Fonterra Co-operative Group Limited, *Fonterra Annual Report*, 2009.

³³ The New Zealand Dairy Research Institute was established in Palmerston North in 1921. This became the Fonterra Research Centre in 2002.

³⁴ Palmerston North City Council, *Sector Profiles 2009: Research, Science & Technology*, 2009.

<http://www.pncc.govt.nz/content/65774/R,%20S%20and%20T%20Profile-web.pdf>

³⁵ <http://www.foodinnovationnz.co.nz/>

does have a strong commitment to New Zealand, managers emphasize that in forming R&D partnerships, they seek out the world's best researchers and research organizations, whether at home or located abroad. Proximity to customers is also important, and Fonterra has built up its Chicago technical centre (around which many major customers are located) to rapidly improve its response time to production line innovation requests from months to weeks or even days. Fonterra also continues to build upon a strong research and innovation base participating in and building on government-initiated partnerships and projects, government support for efficiency-measures and improved productivity among dairy farmers, and levy-funded farm extension services. Fonterra indicates that it has close relationships with government, not only at high executive levels, but also in terms of working relationships with agencies, and there are multiple opportunities for dialogue and consultation in developing R&D and innovation policies. Fonterra puts ideas forward to, and competes for research support from, New Zealand's Foundation for Science and Research (FORST). With government supports (50%), Fonterra takes on about 40 undergraduate student interns each year and provides them with 3 months of project experience in food science and related food-manufacturing areas. In short, there is an intensive and supporting set of public and public-private relationships, capabilities, and mechanisms which Fonterra is able to engage with and build upon as it implements its own R&D and innovation strategies.

Flavorjen

An Auckland-based company, established in 2000 by an executive with experience in the innovation unit of the Kiwi Dairy Group (one of Fonterra's predecessor companies), it provides customized flavours and natural substitutes for use in dairy products. It offers three major lines: enzyme-based natural dairy substitutes for cheese, butter, and cream; natural fruit flavours for dairy products such as yoghurts and processed fruits; and soy products used in food processing and as antimicrobial additives to control food spoilage.

Its key selling points are that its natural products can lower the cost of dairy products, reduce fat while maintaining flavour and texture, lengthen product life, and substitute for artificial flavours and additives.

At the other end of the size scale is Flavorjen³⁶ - employing 6 people. Flavorjen sources its products from Jeneil Biotech, Inc., based in Wisconsin, USA, manufacturing natural food flavours. Its value-added is in working with food manufacturers to effectively apply flavour technologies and natural enzyme products and in developing new products which manufacturers can make and market, one example being "Mr. Cheese" - pasteurized cheese in an aerosol, without artificial colours or additives, developed by Flavorjen and manufactured and marketed by the Tatua Co-operative in New Zealand.³⁷ Flavorjen sells its services to food companies in New Zealand and internationally, offering customized expertise in projects (short and long term) to develop or enhance food lines.

Flavorjen draws on local food research infrastructure in links with Massey University on various projects and on a proposed new food innovation centre in Auckland, with Otago

³⁶ <http://flavorjen.com/>

³⁷ <http://www.tatua.com/Consumer-Products/Consumer-Products-Aerosol-Cheese>.

University on food technology research, with the Plant and Food Crown Research Institute in food biotech and flavour research. It uses a networked approach for larger projects, drawing on external engineering expertise when helping companies to build production lines or nutrition expertise for new product development. Flavorjen has also benefited from grants and services provided by TechNZ, the business investment and commercialization programme of the Foundation for Research, Science and Technology. This infrastructure, and the cluster of food sector companies and organizations in Auckland, is important to Flavorjen. The company is a positive example for the role and potential of small yet highly capable intermediary players in product enhancement and value-added services in fostering innovation in the well-established food industry.

A central component of the public support for innovation in the food sector is Plant & Food Research - one of eight Crown Research Institutes (CRIs) in New Zealand.³⁸ Plant & Food Research was created in 2008, from the merger of two other CRIs - HortResearch and Crop and Food Research. Plant and Food employs about 900 researchers and staff, with 2009 revenues of NZ\$92.3 million (£42.2 million). Just over one-half (51%) of Plant and Food's 2009 revenues are from commercial science research; the balance comprises crown-funded research contracts (46%) and other sources (3%).^{39,40}

The major challenges facing the new institute include continuing to enhance an innovative business-oriented research culture and deploying its scale and capabilities to pursue integrated approaches to addressing problems and opportunities in the primary products and food sectors.

There is an ongoing effort to adjust from an investigator-led public research orientation to a client-led focus engaging interdisciplinary teams. Among the strategic areas targeted by Plant and Food include efforts to foster elite cultivar development - fruits, vegetables and crops with special qualities, sustainable production systems, and new functional foods. The institute has several research centres in New Zealand, with three larger facilities in Auckland, Palmerston North, and Christchurch. There are also associated marketing and consultancy operations in Australia and the United States. Multiple research

Crown Research Institutes (CRIs):

CRIs are corporatized organizations, formed in the 1990s from government scientific and industrial research units and labs, to undertake research and to transfer it to industry and other users. While CRIs receive some public funding to maintain and develop capabilities, they are required to operate as commercial entities, seeking private funds and competing for available public research programmes and projects. In 2009, the combined revenues of all CRIs (from public and private sources) totalled NZ\$625 million (£286 million) and they employed about 4,400 researchers and staff.

³⁸ The eight current Crown Research Institutes (CRIs) are: the New Zealand Pastoral Agriculture Research Institute (AgResearch); the New Zealand Institute for Plant and Food Research (Plant & Food Research); the Institute of Environmental Science and Research (ESR); Scion (New Zealand Forest Research Institute Limited); GNS Science, the Institute of Geological and Nuclear Sciences; Industrial Research Limited (IRL); Landcare Research; and the National Institute of Water and Atmospheric Research (NIWA). The CRIs are monitored by the Crown Ownership Monitoring Unit of the New Zealand Treasury (<http://www.comu.govt.nz/crown-research-institutes.html>). Science New Zealand (<http://www.sciencenewzealand.org/>) is the organization that represents the 8 CRIs.

³⁹ Plant and Food Research, *Annual Report 2009*.

⁴⁰ These annual results include several months trading as the two earlier institutes.

partnerships have been developed with New Zealand universities and the institute participates in a tertiary-education centre for research excellence involving Massey, Lincoln and other universities supporting more than 40 research students and post-docs. Plant and Food is involved in other public and private network initiatives, including the Biopolymer Network Ltd which involves three CRIs and FORST in research to create new bio-composite products and structures from biologically-produced materials (rather than petrochemicals).⁴¹

Plant and Food also works with export-oriented companies and sector organizations on customized research projects. Such sector organizations can to draw on levies on individual farmers and growers to sponsor research with Plant and Food Research. The institute reports that it developed 105 new and improved processes in 2009, secured 13 New Zealand patents and 10 overseas patents, entered into 8 licensing agreements and 5 joint ventures/associations, and spun-out one company (which joined a small group of companies spun-out from the prior institutes). Revenues from various types of intellectual property total about NZ\$10 million (£4.5 million) annually. The institute admits is more interested in developing partnerships and licenses for its new technologies and crop varieties rather than spinning-out companies. At present, about 10% of revenues are generated from outside of New Zealand, although it seeks to grow this part of the business through initiatives such as Food Innovation New Zealand.

Advanced Manufacturing and Materials

The manufacturing sector in New Zealand is comparatively small - it employs about 12.7% of the labour force and contributes 14.1% of GNP. Food processing is the largest component of the New Zealand manufacturing sector, accounting for 45% of all sales of manufacturing goods and services in 2008. The core grouping of metal products, machinery and equipment, and transportation equipment accounted for 23% of sales of manufacturing goods and services in 2008. In the same year, the resource-based processing group, comprising wood and paper products, petroleum and coal products, and non metallic mineral products, comprised about 22.5% of manufacturing sales, followed by other industries such as textiles, furniture, and printing which accounted for the balance (just under 10%).⁴² New Zealand manufacturing enterprises are typically small-scale: enterprises employing fewer than 20 employees comprise 91% of the country's 21,900 enterprises and employ about one-quarter of New Zealand's 240,000 manufacturing workforce. Conversely, only 2% of New Zealand manufacturing enterprises employ more than 100 employees, although these firms employ more than one-half of the country's manufacturing workforce.⁴³

Included in the advanced manufacturing and materials sector are companies engaged in making machinery and manufacturing systems, imaging and sensing technologies, electronic and mechanical products, and composites and other new materials.

⁴¹ <http://www.biopolymernetwork.com>

⁴² The Treasury, 2009, op. cit.

⁴³ Calculated from: Statistics New Zealand, Statistics New Zealand, *Enterprises, Geographic Units, and Employee Count*, by ANZSIC06 division, February 2009.

While these are generally high-value added products, New Zealand firms face challenges of a small home market and distance from major international markets, plus the broader challenges of global competition, including competition from lower-wage locations (particularly in Asia).

Fisher and Paykel Appliances is a prominent New Zealand-based manufacturer that has restructured its operations in the face of intense competition at home and abroad to meet these challenges. By 2009, F&P had accumulated bank debts estimated at over NZ\$500 million⁴⁴ (£225 million), and restructured its relatively high cost local manufacturing plants, relocating to Thailand, Italy, and Mexico. The company continues to innovate, introducing a draw-based dishwasher, and R&D remains concentrated in Auckland. However, F&P's R&D spending has fallen⁴⁵ - from 1.23% of revenues to 0.88%. As a relatively small player in the global appliance segment (with about 400 people engaged in R&D, engineering and innovation compared to a reported 40,000 engineers in competitor Samsung (South Korea) forming strategic partnerships is critical for survival. The company has a strategic relationship with Whirlpool (USA), although this has not led to breakthrough products. A new relationship is being developed with Haier, a Chinese electrical appliance manufacturer, which has acquired a 20% stake in F&P. This will launch the F&P brand in China, and the companies have agreed to cooperate in product development, manufacturing and marketing. Domestically, F&P has drawn on government R&D tax credits (now repealed) and used other training programmes. However, links with universities in New Zealand are not strong. The company indicates that it does not at present have the resources to develop large-scale research programmes with universities. It has had some small projects and does hire university engineering and other graduates, but there appear to be few other strategic links. F&P has a tradition of being vertically-integrated, and it now seeks global partners to increase market access and lower production costs. Its former strategy of competing from a New Zealand base through innovation is now replaced by a global manufacturing strategy.

Although F&P's relationships with New Zealand universities have been limited recently, the universities have been increasing their efforts to link with companies, primarily

Fisher and Paykel Appliances:

Fisher and Paykel Industries was founded in 1934, first as an importer of household appliances, and subsequently as a manufacturer of appliances in New Zealand (initially with government tariff protection). With subsequent liberalization and tariff removal, the company emphasized innovation, with leadership in the development of direct drive systems in washing machines, in factory automation and just-in-time production. Internationalization accelerated in the late 1980s, with the first overseas plant (in Australia) and entry into European and other international markets in the 1990s.

In 2001, the business split Fisher and Paykel Appliances (F&P), and Fisher and Paykel Healthcare. F&P made corporate acquisition of appliance makers in the US and Italy, focusing on producing technologically-sophisticated and well-designed ovens, dishwashers, washing machines, refrigerators and other home appliances commanding premium market positions.

⁴⁴ "F&P hasn't asked for govt help, Key says," *Findata* February 16, 2009.

⁴⁵ Fisher and Paykel, *Annual Report 2009*.

small and medium-sized enterprises (since the country lacks large-scale manufacturers). New Zealand universities have traditionally focused on academic curiosity-driven research, so an underlying challenge has been to gain recognition for, and increase the role of, applied industry-focused research. The government has been keen to encourage this shift. For example, the Plastics Centre of Excellence was established in 2008 as a collaboration between the University of Auckland and Plastics New Zealand. The latter is a trade association with over 180 member companies or about three-quarters of all companies engaged in plastics manufacturing, design, machinery and associated sectors in New Zealand.⁴⁶ The Centre was initially funded through a grant of NZ\$5 million (£2.25 million) provided by the government and

matched by Plastics New Zealand. The Centre seeks to foster innovation in the New Zealand plastics sector through research on advanced polymeric materials, customized research projects, training, and technology transfer.⁴⁷ Both this and the STIC models are focused on traditional industries, and seek to engage researchers in applied work. Importantly, the funding model encourages industry leadership, while the STIC model has the advantage of an ongoing private sector contribution to applied R&D.

Industrial Research Limited (IRL) - the Crown Research Institute tasked with supporting New Zealand industry - has also developed initiatives targeted at core manufacturing sectors. With 320 researchers and staff, IRL is organized in three major clusters: advanced manufacturing technologies (including energy and materials, engineering and applied physics, and high temperature superconductors); industrial biotechnologies; and measurement standards. Formerly part of the government Department of Scientific and Industrial Research, IRL is continuing a transition from a researcher-led to client-led orientation. In 2009, 72% of its revenues of \$NZ60.5 million (£27.2 million) were provided by government, with 26% from commercial sources and it secured 10 New Zealand patents, 20 overseas patents, 8 licensing agreements, 5 joint ventures and developed close strategic linkages with 5 high-potential companies.⁴⁸ IRL undertakes applied commercially-oriented research as well as fundamental platform research for future technologies. The relatively low share of commercial funding for IRL's research effort in part reflects some lack in R&D awareness and investment among New Zealand manufacturers. To tackle this problem, in 2009 IRL launched the "What's Your Problem New Zealand" programme and initiated a competition to select a company to receive \$NZ1.0 million (£450,000) of IRL R&D services. A

Structural Timber Innovation Company (STIC):

The University of Auckland has partnered with the University of Canterbury, several wood products companies, an industry association, and Forest and Wood Products Australia to establish the Structural Timber Innovation Company (STIC) in Christchurch.

STIC is pursuing research on innovative and sustainable approaches to using timber for large-span non-residential applications that typically use concrete or steel. The core funding model for STIC involves FORST R&D funding matched by industry funds. Companies pay up to NZ\$100,000 (£45,000) a year to belong to this consortium, which also gives rights to use or license any IP developed.

⁴⁶ <http://www.plastics.org.nz/>

⁴⁷ <http://www.plasticscentreofexcellence.org.nz/>

⁴⁸ Industrial Research Limited, *Annual Report 2009*.

major marketing and publicity effort was initiated, the idea for which initially came from a group of IRL staff.⁴⁹ Companies were asked to submit R&D project requests. Of 100 applications received, 10 were selected for review by an independent panel. The winning company, Resene, was awarded the prize to develop water-based paints made from resins using ingredients that were up to 80 percent sustainable ingredients.⁵⁰

Although only one prize was awarded, IRL reports that the competition not only increased visibility and also awareness of how companies might use IRL's services, it generated engagements with companies other than the winning firm. While not designed as a complete solution to problems of weak industrial research in New Zealand, the competition represented an innovative, fresh approach to raising awareness about R&D opportunities and improving the interface between applied research and industry.

Financial Services (and Advanced Business Services)

The mid-1980s is a landmark period in New Zealand's financial services sector, with government reforms to reduce regulations, open up markets, reduce trade protection, and float the currency.⁵¹ Value added in New Zealand business services, including banks, insurance and real estate, grew from 15.5% of the national total in 1978 to 28.3% in 2003 - comparable to the OECD average of 28.4%.⁵² Growth in financial services was regarded as generally low through to 2001, but subsequently increased through to 2007, facilitated by the openness of the New Zealand market, and the related entry of large foreign-owned financial organizations, and by access to credit which fuelled commercial and consumer demand for financial and real-estate services. While there are more than 28,000 enterprises in New Zealand's financial and insurance services sector, more than three-quarters of all employees are employed by about 60 enterprises. Similarly, in the information media and telecommunications sector, three-quarters of all employees work in about 40 enterprises out of nearly 4,900 in that sector. On the other hand, in rental, hiring and real estate and in professional, scientific and technical services, there is a greater role in employment for smaller enterprises: in these two services sectors, enterprises with fewer than 20 employees employing 62% and 42% of all employees respectively.⁵³

Several challenges face the financial and advanced business services sector. In the financial sector, there is a problem of scale. While Auckland is the largest centre in New Zealand for financial, insurance, and other advanced services, it is subordinate to Sydney and Melbourne in the Australasian region and overshadowed by the leading regional locations of Tokyo, Singapore, and Hong Kong.⁵⁴ After a period of openness, the New Zealand financial sector has seen significant merger, acquisition and consolidation activity in recent years, resulting in the ascendancy of four Australian-owned banks in the New

⁴⁹ "Eureka Moment' Leads To Development Of \$1 Million R&D Competition," *Scoop*, March 17, 2009, <http://www.scoop.co.nz/stories/SC0903/S00034.htm>,

⁵⁰ http://www.resene.co.nz/comn/whtsnew/eco_winner.htm

⁵¹ Reserve Bank of New Zealand, *The Reserve Bank and New Zealand's Economic History*, 2007.

⁵² OECD Factbook 2009, op.cit.

⁵³ Calculated from: Statistics New Zealand, February 2009, op.cit.

⁵⁴ Ascari Partners, *Economic Futures: Understanding the Business Services Sector in the Auckland City Region*, Auckland, 2008.

Zealand financial sector and restructuring in the insurance sector. Increasingly, there are concerns that major private financial decisions are made outside of the country, while some non-bank financial institutions have encountered difficulties, leading to loss of investor confidence. There is ongoing dialogue in New Zealand about the effectiveness of banks and other financial mechanisms in providing debt and equity capital for businesses, especially those of small and medium-size.

In other areas of advanced business services, such as media and software development, New Zealand has garnered a reputation for innovative small start-ups. However, in seeking to grow, such firms face a series of issues including limited domestic market scale, distance from global markets, competition for skilled talent, and access to capital and electronic infrastructure. In several cases advanced business services firms have been acquired by foreign companies and/or moved offshore. In one example (in 2006), the government provided a subsidized loan to retain the R&D facilities of a leading graphics software company in New Zealand.⁵⁵ There have been some notable successes in film production, and the New Zealand Government offers incentives to attract foreign film makers, support domestic productions, and aid post-production and digital effects activities within the country.

IAG New Zealand, a subsidiary of Insurance Australia Group, is one of the leading insurance companies operating in New Zealand. IAG was formed from the demutualization in 2000 of the Australian NRMA Insurance Group. IAG subsequently entered the New Zealand market by purchasing two long-established companies – State Insurance in 2001 and NZI (New Zealand Insurance) in 2003 – and several other local companies including Swann Insurance and NAC Insurance. Over 1800 people are employed in New Zealand by IAG, headquartered in Auckland. The company holds about 35% of the New Zealand general insurance market and wrote premiums in excess of \$NZ 1.1 billion (£519 million) in 2008.⁵⁶ An interview with a senior AIG manager indicated that within the company the core factors for fostering productivity, innovation and competitiveness include staff training, management of staff turnover, and ensuring that customer needs are met. As with other insurance companies, IAG seeks to provide customer service, understand and price risk, manage costs, and work with customers to reduce risk.⁵⁷ Different units within IAG New Zealand pursue different strategies and markets. For example, NZI works through brokers and focuses on business insurance. State uses sales centres, direct customer contact and targets consumer insurance.

The New Zealand insurance market is relatively unregulated. Unlike other developed countries, there is no insurance regulatory commission. There is an industry group, the Insurance Council of New Zealand, which peruses its own “self-regulatory” approach.⁵⁸ The Council suggests that this approach avoids bureaucracy and cost. Company personnel do interact with government agencies on ad hoc specific topics, for example on climate change adaption and mitigation. IAG New Zealand has pioneered the integration of

⁵⁵ Ministry of Economic Development, *Right Hemisphere Loan Agreement*, 2006.

http://www.med.govt.nz/templates/ContentTopicSummary____22215.aspx.

⁵⁶ http://www.seeonline.co.nz/Templates/IAGHome08/pdf/IAG_Our_Performance.pdf

⁵⁷ <http://www.iag.co.nz/About-IAG-NZ/Our-Strategy/>

⁵⁸ <http://www.icnz.org.nz/about/environment.php>

economic, social and environmental reporting of its performance. Measures include customer satisfaction and renewal, staff turnover, role and pay of women in the company, workplace safety and employee engagement, premium revenue, return on equity, market share, and CO₂ emissions.⁵⁹ “Addressing our social and environmental performance as well as our economic performance is simply good business,” states Ian Foy, the company’s Chief Executive Officer.⁶⁰

The contemporary insurance sector tends to be dominated by large companies. The case of Pinnacle Life – a small start-up specialist life insurer with fewer than 10 employees in Newmarket, Auckland – is particularly interesting. Pinnacle Life was established in 1998 by Noel Vaughan, a life insurance industry veteran and actuary. From the onset, the company has focused on selling life insurance directly to consumers – thus avoiding the cost of the intermediary brokers who conventionally sell life insurance. In 2007, Pinnacle became the first life insurance company anywhere to enable a customer to obtain life insurance directly through the Internet, using a customized intelligent approach developed by a New Zealand software company Intelligentlife. The company’s paperless process and focus on simple, straightforward products means that Pinnacle is able to offer life insurance at the lowest price. Pinnacle Life has won international awards for the design of its website and for innovation that directly benefits customers (as opposed to just cutting costs for the insurer).⁶¹ Revenues have grown to \$NZ5 million (£2 million) annually – as yet, just a small share of New Zealand’s NZ\$800 million (£360 million) life insurance market, although Pinnacle seeks to expand its revenues five-fold over the next few years.

Pinnacle’s entry as a small start-up in a market dominated by large well-established players is unusual. It has been facilitated by New Zealand’s liberal financial regulation rules. However, also important in Pinnacle’s rise is the role of a seasoned industry executive, the willingness of private investors to provide risk capital, and the deployment of innovative marketing approaches pioneering the use of the Internet to sell life insurance directly. The products that Pinnacle sells are simpler, but they are also about 20% cheaper than competitors, as brokers and paperwork are eliminated. This is not intrinsically a new business model – low-cost airlines have also pursued similar approaches in taking on established competition. However, it is a model that is less common in life-insurance, and there are insights to be gleaned about how regulators and policymakers can encourage competition in otherwise oligopolistic financial service markets to the broader benefits of the economy and consumers.

Orion Health is another example of an innovative New Zealand company, in this case in the area of health IT systems. Based in Auckland, Orion provides clinical workflow and information technology for medical providers and health care managers, including access to and integration of electronic healthcare records. The company was founded in New Zealand in 1993 to address early efforts in New Zealand to build a national health records systems. After projects with New Zealand agencies as lead users, Orion has

⁵⁹ <http://www.seeonline.co.nz>

⁶⁰ <http://www.seeonline.co.nz/Site/2008/CeoStatement/CeoStatement.aspx>

⁶¹ “2008 INNovator of the Year, *Scoop Business*, September 16, 2008.

<http://www.scoop.co.nz/stories/BU0809/S00329.htm>

expanded internationally with a branch in the US, and offices in Australia, Canada, the UK and Spain. The company employs about 250 people worldwide, with 150 people in New Zealand. Although one of the leaders in its niche, Orion is still a midsize (rather than large) company and it has needed to develop strategic relationships to support its global activities. The company has longstanding relationships with New Zealand Trade and Enterprise (NZTE), a government agency which helps New Zealand firms to export and access international markets. Orion used NZTE's Beachhead programme to set up operations in California.

The NZTE Beachhead programme is targeted at companies with aggressive international growth plans (e.g. at least NZ\$5million in annual revenues and plans to expand to \$NZ100 million) and provides support through specialist advisors in international markets, business development assistance and introductions to potential customers, branding and (in Dubai and Tokyo) access to office space. The New Zealand Ministry of Foreign Affairs and Trade (MFAT), including through its Ambassadors in foreign countries, has supported the company through providing high-level access to senior decision makers abroad.

Orion has also received R&D support from FORST on a 50:50 matching basis to develop new software technologies and has been provided with salary assistance to support summer interns. Company managers have also worked with universities in developing software training and education programmes. The company finds that it is able to attract software developers, both within New Zealand and internationally (since New Zealand is seen as an exciting place to work), and while the New Zealand market is relatively small, it has benefited in the past from efforts by national and local health services to foster innovation approaches to health IT, although company managers observe that there has been some slowing down in New Zealand in recent years in health care IT innovation demand. However, the company has established a base from which to successfully tackle international markets, often teaming with larger players as necessary (such as GE) to enter those markets. Orion presents a model case where government initiatives appear to have been effective in helping a small yet technologically-advanced services company to internationalize and grow.

Findings

New Zealand offers an ideal environment for primary and food production, and exports of commodity products, high-value added ingredients and products, and related services remain critical to the country's economy and trade. It is important to emphasize the role of public-private partnerships, globally-oriented producers, strong R&D capabilities, and strategic policy support in maintaining and strengthening New Zealand's position.

Although agriculture and food production may be seen as a "mature" sector elsewhere, in New Zealand these sectors are the focus of intense and targeted efforts to foster innovation, productivity and competitiveness. Government has undertaken widespread reforms, from the elimination of subsidies to the restructuring of research institutions, with the aim of improving the overall performance and exporting, and supported efforts to raise quality, reputation, and branding, and apply new technologies to improve production processes, new crop and plant varieties, and functional foods. The

restructuring of domestic farmer cooperatives into the global dairy giant Fonterra is a remarkable achievement. Yet, there are also opportunities for new entrepreneurial small firms to develop within supply chains and add value to food production processes and products through advanced techniques and services. New Zealand has sensibly targeted biotechnology growth efforts in sectors and niches where it has some comparative advantage such as agri-bio and plant-bio. Private sector activities are supported by a rich and highly capable research and university research infrastructure, with an increasingly strong user and client orientation and a willingness to collaboratively develop networks and initiatives to pursue new opportunities.

It has been estimated that there are only about 120 companies in New Zealand spending over NZ\$1 million (£450,000) annually on R&D. Government and industry has recognized this as a problem. There has been some uncertainty about how best to apply fiscal incentives for R&D. A broad R&D tax credit has recently been eliminated by the current government on the grounds of ineffective targeting. This action has attracted business criticism, although other incentives and schemes to encourage business R&D are still in place. On the other hand, there has been consistency in the institutional incentives placed on New Zealand research organizations and universities to focus additional efforts to applied research and commercialization. Significantly, the best of these initiatives all involve industry participation and leadership, including through requiring matching industry funds.

New Zealand's approach towards advanced services reflects a mix of policies. At the broadest level, market policy seeks an appropriate balance between regulation and risk-taking. A phase of tight government control has been followed by market liberalization and openness. This has encouraged new domestic entrants, although also allowed larger international companies to acquire larger New Zealand incumbents, particularly in banking and other financial services. Sector policies have been pursued for a few targeted high-value services sectors, such as creative industries. Services companies link with universities to foster general improvements in undergraduate education, although university-industry linkages for services-related R&D (outside of IT development) appears less strong. Recognizing the limited domestic market and the opportunities for companies to develop internationally, government agencies have an outward orientation and various programmes and networks provide support for SME internationalization.

4.2 Business and Policy Environment of Singapore

Singapore is an island-state situated at the southernmost tip of Malay Peninsula, covering a land area of about 700 square kilometres. It experienced an immigration influx over the last two decades, partially as a result of the Government's drive. The population residing in Singapore is estimated at more than 4.99 million (June 2009) of which 1.25 million people are non-nationals.⁶² Except for a strategic geographical location, excellent natural harbour and a trained workforce, Singapore over its short national history (since 1965) has experienced high land cost, no fresh water supply or other natural resources.

Singapore had an atypical economic structure, with few primary sectors like agriculture, farming or mining. Manufacturing was the most important sector accounting for about 21% of GDP in 2008, followed by business services, financial services, tourism, and wholesale and retail trade totalling some 72% of its GDP in 2008. The wholesale & retail trade accounted for some 15% of GDP in 2008, with financial services having the same proportion. The chemicals industry (including petroleum, petrochemicals and speciality chemicals) is the largest in Singapore's manufacturing sector, accounting for almost 40% of total manufacturing output.⁶³

Financial Services (and Advanced Business Services)

Singapore embarked on its development as an international financial centre in the 1960's. The Government had strategic foresight and took first mover advantage in launching the Asian Dollar market in Singapore in 1968, providing Asia's equivalent of the Eurodollar market for foreign investors. Singapore developed its stock and gold exchanges in subsequent years, and when exchange controls were lifted in 1978, Singapore launched its monetary exchange and financial futures market. Over the thirty years, the financial centre grew in scope and size incorporating over 700 institutions. Singapore hosts many of the world's major banks, with a number of foreign banks setting their regional office for Asian operations in

Monetary Authority of Singapore:

The Monetary Authority of Singapore Act of 1971, led to the formation of Monetary Authority of Singapore (MAS) to facilitate the development of a coherent policy on monetary matters. The MAS combined the functions of several government departments and agencies associated with the activities of a central bank.

In April 1977, the Government added the regulation of the insurance industry to the MAS and transferred the regulatory functions of the Securities Industry Act (1973) to the MAS in September 1984. From 1 October 2002, the function of currency issuance was also transferred to the MAS. The MAS conducted monetary policy, managed the country's foreign reserves and government securities, supervised the banking, insurance, securities and future industries, oversaw the function of currency issuance, and promoted Singapore as an international financial centre in partnership with the private sector.

⁶² This information is provided by ASTAR in their presentation to the DETI PIC SOE Project In November 2009.

⁶³ Singapore's Annual Economic Survey (*Principal Statistics of Manufacturing by Industry Cluster*), 2008, Ministry of Trade and Industry.

Singapore.⁶⁴

There are 162 banks registered in Singapore, with only a handful of domestic banks. The sector employs about 60,000. In addition to the three largest domestic banks (DBS, UOB and OCBC) and a dozen others that were recently allowed to offer full banking services (e.g. HSBC, CitiBank, MayBank) to the domestic retail market, the remainder offer only corporate or wholesale services, or serves the Asian Dollar market. Other than banks, the centre has 218 insurance and brokerage companies, 118 fund management firms, 94 securities companies, 69 financial advisory firms, 47 futures brokers and 37 companies dealing with corporate finance and treasury services.⁶⁵

Singapore's foreign exchange market is thriving remarkably as the second largest in Asia and the 5th largest in the world.⁶⁶ Singapore has the largest stock market in Southeast Asia with deep and liquid capital of S\$671 billion in 2008, and 770 listed companies, of which more than 200 are global.⁶⁷ Singapore is also considered a leading asset management location owing to Assets Under Management (AUM) with assets of over S\$1 trillion. The insurance industry of Singapore is also thriving where 16 of the top 25 global reinsurance groups as well as 5 of top 10 global insurance and reinsurance brokers have branches in Singapore. The recent five-year liberalization programme (1999-2003) in financial services had a significant impact, resulting in the formation of three local banking groups. The local arena (both local and foreign banks instituted in Singapore) had been well protected⁶⁸ by the MAS for a long time and greater competition from foreign banks was expected. By 2004, seven local banks consolidated to become three large local banking groups: Development Bank of Singapore (DBS), United Overseas Bank (UOB) and Overseas Chinese Banking Corporation.

UOB Kay Hian:

United Overseas Bank (UOB) was founded in 1935 as United Chinese Bank to serve the Fujian community in Singapore. As a result of opening its first overseas office in Hong Kong, the bank changed its name to UOB. In 1971 and 1972, UOB acquired the domestic Chung Khiaw Bank and Lee Wah Bank, whilst maintaining their identities. Later, the UOB Group acquired the Industrial Commercial Bank (established in 1953 to finance post-war businesses) and Far Eastern Bank (established in 1958 for resumption of businesses). The UOB Group decided to merge the Industrial Commercial Bank with the Far Eastern Bank in 1994; and absorbed Lee Wah Bank into the parent UOB.

Kay Hian & Co was one of the successful securities firm formed in 1970 that maintained joint ownership over the years with HSBC and James Capel Holdings. It subsequently merged with the UOB Securities Ltd in 2000. Over the last decade, it has successfully acquired other securities firms such as remisier base from Credit Suisse First Boston, JM Sassoon and RHB - Cathay Securities Pte Ltd. UOB Kay Hian Holdings is now the largest securities firm in Singapore with about 1500 employees.

⁶⁴ The main sources of information in this section are the Monetary Authority of Singapore and Singapore Official Statistics.

⁶⁵ Financial Connect Singapore. [Available at <http://financeconnectsingapore.com/financesector.php>]

⁶⁶ Bank for International Settlement [Available at http://www.bis.org/publ/qtrpdf/r_qt0712.pdf]

⁶⁷ MAS Website [Available at http://www.mas.gov.sg/fin_development/Singapore_International_Financial_Centre.html]

⁶⁸ No new licenses were granted for full and wholesale banks since 1970 and 1983 respectively.

We interviewed two of these institutions, OCBC and UOB Kay Hian, on policies supporting financial institutions' productivity, innovation and competitiveness. In terms of service innovation, SPRING Singapore promotes excellent services delivery and recognises individuals who have delivered outstanding service through the excellent service award for individuals (EXSA) since 1994. The scheme is championed by ten industry associations and SPRING to develop service models for staff to emulate, create service champions and professionalise the services sector. Financial institutions, such as UOB Kay Hian, benefit from skills development grants from the MAS. There are also incentives to upgrade IT infrastructure supported financially by the MAS. OCBC is a beneficiary of training grants and projects on services innovation (Business Excellent Initiatives), provided by SPRING Singapore.

Due to the small industry community in Singapore, there are many opportunities for bankers to meet formally and informally. Bank chiefs meet with the MAS for policy dialogue and feedback according to our interviewees. It was purported that the MAS played a role in encouraging local banks to consider local mergers to prepare for the 1999 liberalisation. Unlike other sectors that are less regulated, it is felt that Singaporean banks still cannot compete with the international players.

Despite not enjoying scale efficiency, Singaporean institutions enjoyed a high level of technical efficiency due to the nature of international financial services provided at the Centre, i.e. one third of listed companies on the Singapore Stock Exchange are large multinational enterprises seeking access to debt and equity financing.⁶⁹ Over the period between 2000 and 2006, Singapore banking only managed to improve productivity by 1.6% per annum.

It is recognised by SPRING that they have been grappling with service innovation and productivity measurement. Most importantly, Singaporean financial institutions still trailed behind in terms scale efficiency due to the relative scale of inputs due to its size. This is also affirmed during our interviews, that local banks still find it hard to compete with the

OCBC

OCBC Bank became the third largest local bank in Singapore and was controlled by the Lee family. It was founded in 1932 through the amalgamation of three former banks serving the Fujian community in Singapore – Chinese Commercial Bank Ltd (est 1912), Ho Hong Bank (est 1917) and Overseas-Chinese Bank (est 1919). OCBC bought the Four Seas Communication Bank (est 1906) and the Bank of Singapore (est 1954) to prepare for new competitions as the Government encouraged foreign banks to set up offices in the 1970s.

In the early 1990s, the government-linked Keppel Group bought the Asian Commercial Bank and renamed it the Keppel Bank. In 1998, it further merged with the Tat Lee Bank (est 1974) to form Keppel TatLee Bank, which was eventually acquired by OCBC, making it the third largest domestic banking group. As at December 2002 after acquiring Keppel TatLee Bank, it had more than 125 branches and representative offices in 14 countries, including Malaysia, China, Hong Kong, Japan, Australia, UK and USA, making it one of the most networked banks in the region.

⁶⁹ Kuah, A.T.H., Ward, D.R., Doyle, E. and Shapira, P. (2009). *A Comparison of Northern Ireland's Productivity and Efficiency Across Services and Manufacturing*. Report submitted to the Department of Enterprise, Trade and Investment, Northern Ireland.

Qualifying Full Banks (QFB), i.e. those foreign banks that were allowed to compete in the domestic retail market following liberalisation.

Local banks also felt that the Government is very supportive of foreign enterprises, measuring them (including financial institutions) with a different yardstick. Other than the Lehman Brothers products, another example cited was allowing S-Chips Chinese companies (small-cap stocks) to list in SGX. Such second-tier companies are poor in corporate governance and as a result placed the ST Index at risk some years ago.

Food Processing

The food processing sector is relatively small in Singapore, accounting for about 3% of manufacturing output and 5% of employment in manufacturing.⁷⁰ The turnover from this sector in 2006 was SG\$15.2 billion and 40.5% of this was exported.⁷¹ Owing to the size of its domestic market, the sector has to rely on exports. Food exports in Singapore have increased over the 7 years to 2008 and Singapore is the 13th largest Food and Beverage exporter in the world. Asia is the biggest market for food with a share of 63% of exports, and Malaysia, Indonesia, the US and China are the top four markets. The Middle East has been identified as an emerging market for food exports.⁹ Expertise in seafood, possession of advanced technology, and reputation of its hygienic facilities facilitates innovative food products, whilst having access to expertise needed for R&D activities in the sector have generated a cutting edge to Singapore's food sector. The processed food sector consists of about 700 companies, both domestic firms and subsidiaries of the major global food companies (Nestle, Unilever, Procter & Gamble, Kraft, Tate & Lyle, Cadbury's etc). Over the past decade, the output of the sector has increased by 40% despite a decrease in total investments, which indicates the productivity improvement in the sector. The Singapore Manufacturers' Federation (SMA), Food Innovation & Resource Centre (FIRC) and Singapore Food Manufacturers' Association (SFMA) currently collaborate with government organizations such as SPRING Singapore, IE Singapore, and Agri-food &

SPRING Singapore

SPRING is one of 9 agencies under the Ministry of Trade & Industry (MTI). All the agencies work closely together to deliver MTI's vision for Singapore to become a leading global city of talent, enterprise and innovation.

Formerly the Productivity Standards Board of Singapore, SPRING remit now includes small and medium enterprise development. SPRING's mission is to grow competitive and innovative enterprises for a vibrant and robust Singapore economy. SPRING is supporting Quality and Standards of Singapore enterprises by having a well established testing and certification industry in Singapore (since 1973), and raising domestic SME firms adoption of standards (since 1972) to enable them to export to more markets.

In terms of enterprise development, SPRING seeks to (a) develop a supporting environment; (b) seed innovative start-ups; (c) develop supporting clusters; and (d) grow innovative growth-orientated firms, of up to S\$100 million in turnover. Through these, SPRING provides support to upgrade firm capabilities (trade mission, training grants, and management skills), accelerate technology commercialisation and link businesses with

⁷⁰ Singapore Manufacturer's Federation. (2004). 'Trends and Prospects of the Singapore Food, Beverage & Tobacco Industry' SMA Industry Study Series[Available at <http://www.smafederation.org.sg/LinkClick.aspx?fileticket=ccy4a2FngZI%3D&tabid=74>]

⁷¹ General Overview : Food and beverage Industry in Singapore [available at <http://ww2.insis.com/Web/main.aspx?ID=0bf2d245-e8c6-46d5-9304-8030e7ca5859>,]

IE Singapore

Formerly the Trade Development Board of Singapore (est 1983), International Enterprise Singapore's mission is to promote the overseas growth of indigenous Singapore-based firms and international trade. IE Singapore is another agency under the Ministry of Trade & Industry (MTI). It adopts a two prong approach in supporting the internationalisation of firms (overseas investment and services exports) and international trade (goods exports, re-exports, and offshore trade).

The agency adopts a life-cycle approach in helping domestic firms internationalise and gain access abroad. It also facilitates finance schemes for exporting companies, helps develop internationalisation capacities for companies (e.g. branding), and longer term immersion programmes for managers on markets and management.

Veterinary Authority of Singapore (AVA) in order to achieve growth in food processing in Singapore.⁷²

SPRING Singapore is the agency tasked to support SMEs and specific sectors such as printing, food-processing, packaging and retail. SPRING's mission is to grow competitive and innovative enterprises for a vibrant and robust Singapore economy. SPRING highlights that the entire value chain approach is important and states that domestic SMEs which are competitive in supporting FDI in Singapore will

move and grow alongside large firms. SPRING points out that Singapore will benefit as long as the HQ or high value operations are still in Singapore.

We interviewed some domestic food manufacturers, including a promising food exporter and a listed export-focussed food manufacturer SH Donuts is a promising young exporter (established in 2007) producing freshly made gourmet egg-free and *halah* donuts with 13 outlets in Singapore, expanding to Malaysia (2 outlets), Dubai, Indonesia, India, Brunei and China. Its annual turnover is S\$3.5 million and it employs 80 staff in Singapore and 61 staff overseas. The founder, Mr Steven Chiew was noted by then Prime Minister Goh for his enterprising goals. SH Donut was invited by SPRING to participate in the Intellectual Property of Singapore Programme, and received training on Branding. SH Donuts also received

Food Empire

Founded in 1992, Food Empire was listed in 2000 on the SGX. The founder, Mr Tan Wang Cheow, used to trade in electronics and IT components in the 1980s to Russia and Eastern Europe. He identified a niche and founded the company to export an existing innovative product, 3 in 1 coffee mix sachet from the region to an untapped marketplace.

Initially, the company tapped into the excess packing and blending capacity of the leading producer (Super Coffeemix), to produce and then market overseas in this innovative product. Their leading brand, MacCoffee, became the leading coffee brand in Eastern Europe and proves more popular than Nescafe. The company produces and exports frozen finger food/seafood, candy and snacks and 3 in 1 coffee to 69 countries, mainly Russia, Eastern Europe and Central Asia. Food Empire does not distribute their products locally. Its annual turnover is about US\$222 million and it employs about 1028 staff in 4 factories in Russia, Singapore, Vietnam and Malaysia.

⁷² Opening address by Mr sunny Koh, Council member of Sma & chairman, f&b industry group, At the signing of MOU between Sma and RAS 20 July 2009 [Available at http://www.smafederation.org.sg/Portals/0/Publications/Documents/PressReleases/Mr%20Sunny%20Koh%20Speech%2020Jul09_.pdf]

subsidised trade support from IE Singapore in trade missions, which led to setting up branches and factories abroad. PM Goh explicitly encouraged Mr Chiew to consider expanding overseas due to the small market in Singapore.

Food Empire is a past beneficiary of the SPRING loan scheme, and hopes to receive SPRING funding to help local SMEs in step improvisation on new product development. The government has supported highly innovative food manufacturers in general and encouraged them to apply for schemes in automation, environment protection (NEA). Food hygiene standards are maintained by the Ministry of the Environment, where Singapore's tight control on food hygiene is recognised by other countries according to both our interviewees. One particular factor supporting the success of this sector, according to Food Empire, is the work ethic of Singapore's workers resulting in a lower cost base for their production operations when compared to Russia.

Food Empire works with the 5 local polytechnics. Research projects are undertaken with Nanyang Polytechnic and Singapore Polytechnic on different seasonings, flavours, and additives for snacks. In spite the lack of a primary sector, Singapore's processed food exports enjoy good scale and technical efficiency. We find rather innovative products are offered by the two companies interviewed. Singapore's small size can bring certain benefits in terms of collaboration with local higher education providers, and heightened her government awareness of its innovative enterprises.

Chemicals Sector

Singapore's chemicals sector consists of refined petroleum products, chemicals and chemical products, and rubber and plastic products. The sector employs 12.5% of employees in the manufacturing and contributes 40% of the total manufacturing output (with only 14.3% of the establishments in the manufacturing sector).^{73,74} In 2007, its contribution was S\$82 billion, a substantial improvement from S\$39 billion in 2004.⁷⁵ Petroleum accounts for approximately 60% of the sector's output, petrochemicals 30%, and speciality chemicals 10%. Currently the sector has over 1,000 companies including 3M, Evonik Degussa, Huntsman, ExxonMobil, Chevron Phillips and Siltronic. The chemicals and pharmaceutical sector cluster around Tuas and Jurong Island (on the western end of Singapore); Jurong Island is amongst top 10 petrochemical hubs in the world, with ExxonMobil planning to complete the construction of the corporation's largest integrated chemical and refining site in Singapore by 2011.⁷⁶ Shell has announced the investment of a cracker plant of close to S\$1.5 billion and Exxon has decided to invest in a derivative plant of S\$3-4 billion

⁷³ Ministry of Man Power, The Profile of chemical industry in Singapore, [Available at [http://www.mom.gov.sg/publish/etc/medialib/mom_library/Workplace_Safety/bc_chemicals.Par.26931.File.tmp/ Profile%20of%20Chemical %20Industry%20in%20Singapore.pdf](http://www.mom.gov.sg/publish/etc/medialib/mom_library/Workplace_Safety/bc_chemicals.Par.26931.File.tmp/Profile%20of%20Chemical%20Industry%20in%20Singapore.pdf)]

⁷⁴ Annual Economic Survey (Principal Statistics of Manufacturing by Industry Cluster), 2008, from the Ministry of Trade and Industry

⁷⁵ EDB (2008) 'Singapore Chemical Industry Council Organises Jurong Island Open Day To Draw New Generation Of Talent' [Available at http://www.edb.gov.sg/edb/sg/en_uk/index/news/articles/singapore_chemical.html]

⁷⁶ EDB Singapore Chemicals Facts & Figures, Chemicals Factsheet http://www.sedb.com/edb/sg/en_uk/index/industry_sectors/Chemicals/industry_background.html

Singapore mainly serves the petrochemical demand from Asia, and it is expected that in 10 years time, 60% of the world's petrochemical demand will come from Asia.⁷⁷

The Institute of Chemical and Engineering Sciences (ICES), formed under the umbrella of ASTAR, is the public research institute responsible for aggregating R&D activities in the sector; it particular focuses on developing new processes and applications for the chemical industry. The Singapore Chemical Industry Council (SCIC) is the representative body of the chemical industry in Singapore⁷⁸. There also are associations such as the Singapore Plastics Producers and PCS Complex representatives that hold regular dialogues with government agencies like the Jurong Town Corporation (JTC)⁷⁹. Arising from such regular dialogues is the current construction of chemical storage bunkers underneath Jurong Island.

We interviewed Mr Ron Corn, Managing Director of Chevron Phillips, who runs four small reactors on Jurong Island and Tuas. The value proposition of Singapore as a chemical cluster is evident in the quote from Mr Corn: "There are different value propositions in locating in Singapore. It is the doorstep of Asia with a western style management. It is one of the least risky environments, with a government supporting business plans and business continuity ... As many parts of the value chain are found in the Jurong Island, with its many chemical complexes, sources of feedstock and supplies can be found in Singapore, except for crude oil." The country is also interested in developing the knowledge and skills of professionals in this sector which they consider as one of the major competitive strengths. For example, Mr. Corn revealed that there are efforts (including employment credits) to push by the MTI for employing additional graduates in the workforce. Inclusion of additional graduates, he said, may increase the level of innovation in the operations and processes.

The Economic Development Board (EDB) is the lead government agency responsible for attracting and maintaining FDI (foreign direct investment) in Singapore. EDB is the lead government agency under the Ministry of Trade and Industry (MTI) that plans and executes Singapore's economic strategies. It maintains teams organised along the concept of industry clusters to provide a favourable macro level environment (eco-system approach). It aims to

Chevron Phillips Chemical

This company is one of the world's top producers of olefins/polyolefins and a leading supplier of aromatics, alpha olefins, styrenics, specialty chemicals, piping, and proprietary plastics. Chevron and ConocoPhillips (formerly Phillips Petroleum Company) each own 50 percent of Chevron Phillips Chemical, but the entity operates as a separate business.

Phillips entered Singapore in 1982 as a result of government attraction., Chevron (in Caltex) in 1984, and expanded their operations in 1998. CHECK MEANING OF PREVIOUS SENTENCE In Singapore, Chevron Phillips runs four smaller reactors on Jurong Island, Tuas (2x 75 metric tonne, 2 x 125 metric tonne). It owns more than 20 reactors in the US and 2 in Qatar and 3 in Saudi Arabia.

⁷⁷ EDB (2008) 'Singapore Chemical Industry Council Organises Jurong Island Open Day To Draw New Generation Of Talent' [Available at http://www.edb.gov.sg/edb/sg/en_uk/index/news/articles/singapore_chemical.html]

⁷⁸ Singapore Chemical Industry Council (SCIC) [Available at <http://www.scic.org.sg/>]

⁷⁹ JTC is the agencies under the Ministry of Trade and Industry responsible for planning, promoting and developing industrial facilities and infrastructure in Singapore for the past forty years. JTC manages the developments of many industrial developments including wafer fabrication parks, a chemicals hub at Jurong Island, Tuas Biomedical Park, Biopolis and Fusionopolis amongst others.

remove red-tape for investors, provide tax incentives for businesses it is targeting, and supply skilled workforce. The EDB maintains very close contacts with businesses (about 500 people employed by the EDB) that it has attracted over the years (e.g. Chevron Phillips who came in the 1980s). Through the JTC, the Government is investing in large underground caverns for chemical storage on Jurong Island. This planning and support, according to Mr Ron Corn, demonstrates willingness of the Government to invest in industry development.

Emerging Sectors

Boosting the chemicals sector in Singapore is the newly emerged pharmaceutical and life sciences sector, which really started in 2000 when the EDB began actively attracting the major players such as GlaxoSmithKline, Eisai, Merck & Co.⁸⁰, Pfizer, Wyeth, Novartis and Schering-Plough. The country has focused on strengthening its status as research hub for translational and clinical research through the creation of Singapore's R&D Framework with its lead agency ASTAR. Singapore's position as a strong R&D hub for multinational pharmaceutical companies with seven research institutes and five research consortia in key fields that including clinical sciences, genomics, bioengineering, molecular/cell biology, medical biology, bioimaging and immunology. ASTAR-NUS-Siemens Clinical Imaging Research Centre, two Investigational Medicine Units, and the Singapore Clinical Research Institute are the major supporting institutes in this area. On-going developments are the Cancer Research Centre of Excellence and the Centre for Translational Medicine. In terms of education, Yong Loo Lin School of Medicine in the National University of Singapore (NUS) and the Duke-NUS Graduate Medical School Singapore greatly contribute to developing a highly skilled work force.⁸¹

Singapore has established a world class environment and facilities and is on track to develop capabilities that enable companies to carry out "candidate" to "proof-of-concept" drug development. The Biopolis is strategically located next to the Singapore Science Park, which hosts major pharmaceutical and biotech R&D laboratories, the National University Hospital (NUH), and the National University of Singapore's medical school and cancer research centre. The



⁸⁰ *Business Monitor*. Singapore Pharmaceuticals & Healthcare. (2007). Available at http://www.piribo.com/publications/country/asia_pacific/singapore_pharmaceuticals_healthcare.html

⁸¹ Facts and Figure of Pharmaceutical and biotechnology industry by EDB [Available at http://www.edb.gov.sg/edb/sg/en_uk/index/industry_sectors/pharmaceuticals___facts_and_figures.html]

intention, as revealed by ASTAR, is to co-locate public sector research institutes with corporate labs and foster a collaborative culture under one roof. It will allow companies to cut R&D costs by co-sharing expensive facilities and accelerate the development timeline.

More than 10 leading pharmaceutical and biotechnology companies including AstraZeneca, Bayer, Boehringer-Ingelheim, Bristol-Myers Squibb, Genzyme, GlaxoSmithKline, Merck, Quintiles, Sanofi-Aventis and Schering-Plough⁸² have established regional headquarters in Singapore. MerLion Pharmaceuticals concentrates on biotechnology and has been awarded the “Best Company in an Emerging Market” title at the 2007 Annual Scrip awards in London.

Singapore provides a productive destination for research in biotechnology with 1.41 publications per 1000 people⁸³. The country has more than 2,000 national and internationally renowned researchers such as Sydney Brenner (Nobel Laureate, Salt Institute of Biological Science), Judith Swain and Edward Holmes (UC, Berkeley) and Sir George Radda and Colin Blakemore (both from UK Medical Research Council). The objective is to develop knowledge and skills in this sector.

Business Monitor International’s Business Environment Ranking (BER) matrix for the 3rd quarter in 2009 ranked the pharmaceutical market in Singapore as the 6th among 15 leading countries in the Asia Pacific region. The same report values the Singapore’s pharmaceutical market at US \$ 561 million in 2008 and predicts that this market will grow at a compound annual growth rate of 1.52%. Further, the proportion of generic drugs as a percentage of total market is expected to grow from 10% in 2008 to 11.8% in 2013 and also a significant growth is expected with respect to over-the-counter market which will have negative impacts on branded drugs.⁸⁴

Curiox Biosystems

Dr Namyong Kim (PhD Chemistry), a Korean, was attracted to Singapore after graduating and working in the US for several years. He was attracted by ASTAR generous funding and Singapore’s multicultural environment to eventually settle down with his family. After working for several years in ASTAR Institute of Bioengineering and Nanotech as a project leader and having 3 patents, he was encouraged to form Curiox Biosystems in 2008.

As a promising high-tech company, Curiox has received support from IE Singapore in training its staff and marketing its product. It has received support from SPRING Singapore for technology and product development.

Curiox has attracted investors from NanoStart, Walden and Vortex. It has also established distributorship for its product in Korea, US and Japan. The main product is a nanoinstrument that is used in biotechnology sector by pharmaceutical companies like GSK and Lilly.

⁸² Tan, D. and Ng M. (2008). Singapore Biotech Guide 2009/2010. Marshall Cavendish, 1st Phase Operations and Greener Grass.

⁸³ Kuah, A.T.H., Ward, D.R., Doyle, E. and Shapira, P. (2009). ‘Mapping Organizational Capabilities for Innovation and Competitiveness: Research Performance and Patenting in Small Open Economies’. Report submitted to the Department of Enterprise, Trade and Investment, UK.

⁸⁴ Singapore Pharmaceuticals and Healthcare Report Q3 2009 [Available at http://docs.google.com/viewer?a=v&q=cache:SRhTK3cxkPAJ:www.researchandmarkets.com/reports/1055162/singapore_pharmaceuticals_and_healthcare.pdf+singapore+pharmaceutical+industry+statistics&hl=en&gl=uk&sig=AHIEtbQFaEkGLC_zkCey4igCTliIdapBGOQJ]

While the local market remains limited, mostly owing to the limited size, the drug export market seems to be performing well. The country's status as a strong R&D⁸⁵ hub is strengthened by its manufacturing base, tax benefits, political stability, strong IP laws and the availability of high skilled workforce maintains Singapore's competitive position. More than 50 companies are carrying out R&D that straddles drug discovery, translational and clinical research and medical technology innovation. They include GSK, Novartis, Lilly, Takeda, CominotoRx, S*bio, Merlion and PhamaLogicals.

We talked to Dr. Namyong Kim, Founder and Managing Director of Curiox BioSystems, whose main product is a nanoinstrument used in biotechnology sector by pharmaceutical companies like GSK and Lilly. Dr. Kim highlights that Singapore's small size and community have enabled strong personal contact network in garnering collaboration in research. He continues to collaborate with ASTAR and colleagues in NUS. He also finds that the establishment of Biopolis and public research institutes aids in the transfer of knowledge. Admittedly, he acknowledges the local market size does not support his company in the emerging sector, as compared to Korea and Japan which have ten times the number of firms.

The last Economic Review Committee report, completed in Feb 2003, has identified nanotechnology as an attractive emerging sector⁸⁶. Dr Lerwin Liu, one of our interviewees, became an advisor for the EDB for setting up the nanotechnology scene in Singapore. Nanoscience and Nanotechnology Cluster (Nanocluster) established by Nanyang Technological University and Nanoscience and Nanotechnology Initiative (NNI) initiated by National University of Singapore played major roles in terms of R & D activities carried out in this sector⁸⁷. The number of publications and funding in nanotechnology has increased from about 25 and \$54 million respectively in 1997, to about 225 and in 2002 \$516 million in 2003 respectively⁸⁸.

The EDB worked hard to attract new nanotechnology companies and business angels to set up in Singapore (it was found that traditional venture capitalists in Singapore are not technology savvy in this new area), as venture capitalists form an essential part of the eco-system. One particular success was attracting NanoStart to Singapore in 2007, which subsequently funded Curiox Biosystems. Admittedly, Singapore is still quite behind in nanotech development and research compared to Japan and Korea in Asia as revealed by our two interviewees. There are only about 10 active small nanotech companies in Singapore, mainly from NTU and NUS (compared to more than 100 in Korea). Such firms are within 5km of the Universities. They remained small as the industries in Singapore are not (yet) partners to such technology, hence nanotechnology companies do not have a big local market for exploitation.

⁸⁵ <http://www.ibn.a-star.edu.sg/>

⁸⁶ Nanotechnology Research Institute (2003). Nanotechnology in Singapore: Attractive for Global Nano-Partnership. Asia Pacific Nanotech Weekly. Vol 1. Article # 26. [Available at <http://www.nanoworld.jp/apnw/articles/library/pdf/26.pdf>]

⁸⁷ Special issue on nanotechnology in Singapore. (2007) International Journal of Nanotechnology. Vol. 4, No. 4

⁸⁸ SingNano – Singapore Nanotechnology. (2009). Network News Letter Issue 2, August. [Available at http://www.nano-globe.biz/SingNano/NewsletterCover_2.php]

Government Insights

The mission of the Ministry of Trade and Industry is to promote economic growth and create jobs so as to achieve higher standards of living in Singapore. Other than functions in regional investments, world trade, economic planning and monitoring, enterprise and human capital development, the MTI is also responsible for nine statutory agencies (Figure 3). In Singapore, urban planning (by the Urban Renewal Authority, URA) is core in the last three to four decades, resulting in clear economic zones within the country. URA is a statutory agency at the Ministry of National Development. As pointed out by senior officials at the MTI, firms naturally cluster in Singapore due to land scarcity, but more importantly, attributed to good urban planning over the last few decades.

Figure 3: Agencies of MTI: Singapore



Industrial policies at the MTI support an eco-system (cluster) approach to ensure all parts of value creation are “competitive” upstream and downstream in supporting its key industries and enterprises. The eco-system (or cluster) approach is pertinent throughout the MTI agencies (EDB, SPRING, ASTAR, IE) and even at the Financial Services Development Department (MAS) that we spoke to. It was also revealed in the interviews that chief of agencies meet monthly at the MTI, and there was evidence that key personnel movement from one agency to another.

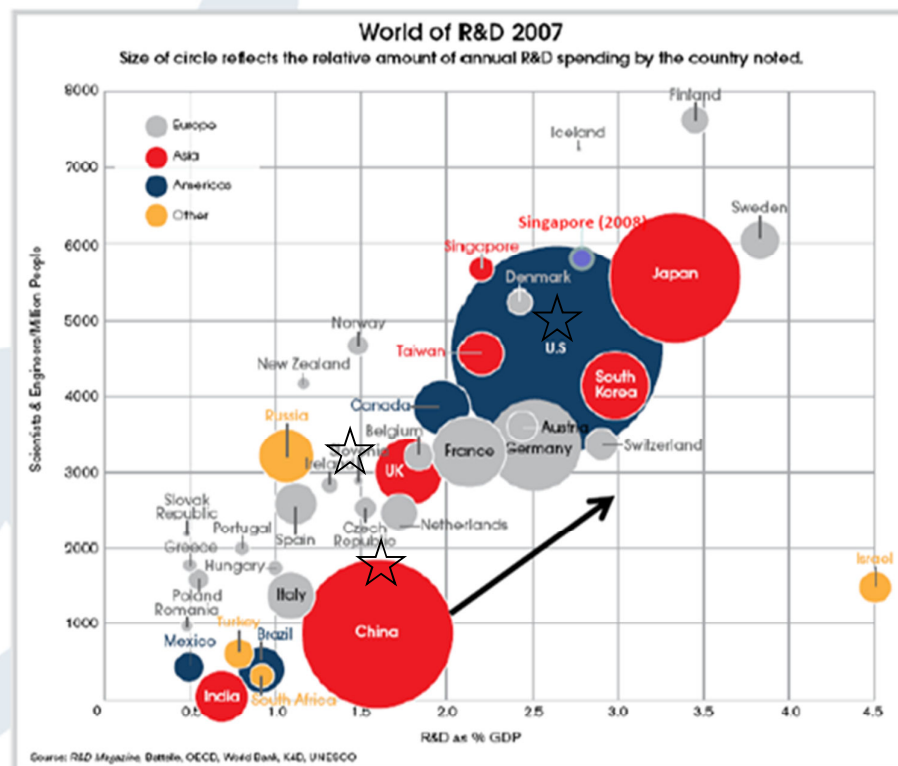
The EDB acts as a central port of call for large businesses and purportedly have direct access to all government ministries. For example, the EDB spearheads meetings with Ministry of Education, SPRING, MAS and Ministry of Health on planning the future workforce requirements in particular to bring in the bio-medical industry. The EDB claims to provide a ‘whole-government approach’ to supporting FDI. The MTI senior officials and

business practitioners we interviewed revealed that the EDB sector officials maintain very close contacts with businesses it has attracted and supported over the years. By working closely with businesses, the EDB notes that business needs are fed to the Government and hence planning and policies can reflect them. This is the bottom up approach that had resonance across the agencies we interviewed. Medium to long term planning (5-20 years) and good execution lead to the success of many strategic plans, the EDB highlights.

Currently, Singapore seems highly focused on innovation (see Figure 4). The national investment in R&D framework to supplement missing link in value chain was made possible after 15 years investment in R&D. Singapore is also beginning to see spillovers from this investment in R&D, with start-ups in nano and biotech small firms (e.g. Curiox Biosystems), although the MTI admits the nation has yet to see its full benefit of its R&D framework. Cross fertilization with industry is also built into this framework with, for example, the GETUP scheme and spin-off firms from ASTAR research programmes.

Figure 4: R&D Spending Comparisons

GLOBAL R&D SPENDING



Singapore's R&D plan will continue towards commercialisation and exploitation, as explained by ASTAR officials (accounting for the high number of patents emanating from Singapore). Monies are ring-fenced for investment in infrastructure and R&D. The Science and Technology Plan covers a 5 year cycle, the most recent being 2006-2010. This cycle is similar across agencies of the MTI and other government departments such as the MAS. The country is committed to doubling spending to S\$13.55 billion over this cycle. Singapore is now closing the gap with other developed economies to target 3% of GERD/GDP ratio (Singapore measures 2.8% in 2008, versus New Zealand 1.7%, Northern Ireland 1.2%, and the Republic of Ireland 1.2% in 2006).

Findings

The productivity agenda in Singapore seems to have been overtaken by innovation and improving service delivery. After more than 30 years focusing on productivity (the National Productivity Board was established in 1972), SPRING's remit now includes small and medium enterprise development and raising domestic SMEs' adoption of standards. Declining productivity in Singapore is still an issue, mainly from the growing services sectors, and ways of measuring its productivity, with which SPRING and MTI are still grappling. SPRING consistently consult with industry on measuring service productivity.

SPRING highlights the entire value chain approach to support firms' productivity is important. Domestic SMEs which are competitive and productive in supporting MNCs in Singapore will move and grow alongside these large firms. They will both benefit as a total entity in exporting competitively. SPRING notes that although some of these may eventually become large exporters, the country will benefit as long as the HQ or high value operations are kept in Singapore.

Singapore's competitiveness is in the execution of system integration. For example, the Port Authority of Singapore (PSA) integrates the logistics systems to create the world's most efficient port. Another example of well-conceived planning and execution includes the R&D framework to integrate the R&D into Singapore's eco-system (including the building of Biopolis and Fusionopolis) integrating key business and universities' research.

The R&D framework articulation is the latest brainchild of the MTI and ASTAR – to complete an entire eco-system to support innovation. Singapore's earlier emphasis on engineering, physics, chemistry and material science research gave its traditional manufacturing sectors a competitive advantage. In terms of patents generated, the focus was strong in electrical, electronics and communication engineering.²³ The next phase is to tap into these existing competencies and direct them towards multidisciplinary innovation to deliver on *Urban Living* (green building, carbon capture, solar energy, water and sustainable development) agenda. With pockets of excellence in medicine, the nation also hopes to develop new areas in *Healthcare* (drug delivery, supporting aging population, medical tourism).

Over the last three decades, the Singapore economy has been able to attract good businesses to provide a fertile ground for high-skilled job creation. ASTAR considers

Singapore's reach of talents and markets of 7 hours flight time from Singapore, going as far as China, India, Japan and Australia, and this consideration is built into their planning. Observations also suggest that this is indeed true as the nation is a conduit to attracting foreigners and expatriates wanting to work in Singapore and some eventually settling down. This may be a testimony to the consistency of economic policies and support mechanisms provided to MNCs. The MTI and SPRING stress that government intervention must be avoided, and instead note that the consistency of policies and industry support/facilitation are key to Singapore's success. IE Singapore locates 74% of its overseas offices within a 7 hour flight distance from Singapore to help provide business intelligence, business networks and partner sourcing for Singapore-based firms.

There is some evidence to suggest that the Government and its agencies operates like a business in its thinking, with good consistency of policies in promoting new industry and supporting domestic firms. Singapore's is now searching for new model of economic success, feeling the pressure of its position as a leading international economy. There is a need to learn how to manage the nation's intangible assets, i.e. the idiosyncratic sentiments of its people and foreign talents needs to be addressed. According to Professor Neo of the Asia Competitiveness Institute, "Singapore has to create an environment where the next winner can be identified either by the people or by the nation".

4.3 Business and Policy Environment – Republic of Ireland

In 2008 the Republic of Ireland had a population of 4.4 million and generated GDP of \$273.3bn with a GDP per capita of \$61,810. Over 40% of the population lives within 100km of the capital city, Dublin. The Republic of Ireland significantly outperformed European neighbours in terms of economic growth and the workforce doubled to 2 million in two decades. The Republic of Ireland has enjoyed a relatively high trend rate of labour productivity growth over the fifty years to 2000 at above 3% (per annum) until the 2000-6 period when it declined to 2.2% (per annum). The Celtic Tiger period saw no increase in this trend rate. The Republic of Ireland's current unemployment rate of 12.5%⁸⁹ represents a rise from 6.4% in 2008 and the perceived natural rate of 4.4% prevailing between 2005 and 2007.⁹⁰ This complicates the policy orientation in the immediate term as focusing on boosting employment requires, arguably, both complementary and alternative approaches and may relegate productivity, competitiveness and innovation concerns to lower priority as immediate needs challenge medium and longer term imperatives.

The workforce is concentrated in the Services sector (67%) with a further 27% in Industry and the remainder (6%) in Agriculture. It is an island nation on the western periphery of Europe exporting 73% of its GDP.⁹¹ The relative size of the Irish economy is 0.27% of the world (expressed in terms of world GDP (in PPPs) for 2008) and the Republic of Ireland has attained a level of living standards (GDP per capita) in the top 10 of all countries.

The most significant export shares relate to Chemicals and related products⁹² at over 57% of total exports, (40% of which were organic chemicals and 40% medical and pharmaceutical products). A further 17% of exports are from the Machinery and transport equipment category with 50% of these from office machines and 25% from electrical machinery. The most significant export partners are the United Kingdom (18.6%), the United States (18.3%), Belgium (14.7%), Germany (7%), France (5.9%) and Spain (4.2%).

Financial Services (and Advanced Business Services)

The sector has expanded rapidly over the decade to 2007 based on strong growth of the Irish economy, latterly predicated on a property bubble, followed by a predictable yet extraordinary bust. By 2008, there were over 42,000 employed across 'traditional' retail banking operations nationally and international banking, mainly in Dublin. Over half of the world's top 50 banks had opened operations in the country and total assets held in this sector amounted to €350bn.⁹³ In total, financial services accounted for around 10% of

⁸⁹ This is the seasonally adjusted standardised unemployment rate (SUR) reported by the Irish Central Statistics Office, in December 2009.

⁹⁰ Relatively high unemployment has characterised the economy historically and even into the middle phase of the so-called Celtic Tiger era remaining in double figures until 1998.

⁹¹ Data taken from Irish Central Statistic Office using annual data for 2008.

⁹² Export data are reported in Standard International Trade Classification (Rev 4) categories and are from the latest CSO figures for 2009 covering the January-September period, representative of the annual trend.

⁹³ Much of this information is provided by Financial Services Ireland, an association of over 180 financial institutions - including banks, building societies, insurance companies, fund administrators and managers,

national GDP, one third of all exports of services, and employed almost 90,000 people. The global credit crunch and property overexposure in the sector has exacerbated the impact of the international slowdown.

Retail Banking in the Republic of Ireland is dominated by the “Big 4” banks, Allied Irish Bank, Bank of Ireland, National Irish Bank (owned by Danske Bank), and Ulster bank (owned by RBS). Heavy exposure to property lending by Anglo Irish Bank, for many years one of the Republic of Ireland’s smallest banks, with most of its €72bn loan book being mainly to builders and property developers, meant that it was badly affected by the downturn in the Irish property market in 2008 and was ultimately nationalised. Mainly a commercial and business bank, its relative size belies its role in the Irish and international property booms and in its impact on the competitive landscape of business banking in the early to mid 2000s. Employment in the retail banks amounted to 31,000 in 2008 working in over 950 head office, regional offices and branches throughout the country.⁹⁴

For this research two Financial Institutions were interviewed - Bank of Scotland (Ireland) and Anglo Irish Bank, with the view to considering their productivity, innovation and competitiveness context and the impact of policy. Further insights were provided by the CEO of the Irish Funds Industry Association relating to the broader financial services, most supplied out of the IFSC.

More than 250 global financial institutions have established operations in the Republic of Ireland, with many located in Dublin’s International Financial Services Centre (IFSC).⁹⁵ The IFSC was created by the Irish Government in 1987 to drive the development of the sector and now houses many of the world’s leading financial institutions as well as a sophisticated support network including accountancy, legal actuarial, taxation, regulatory, telecommunications and other services providers. More than half of the world’s top fifty banks and almost all major global insurers, mutual funds and corporate treasury offices have a presence in Dublin. At the end of 2008, employment stood at over 24,900. All companies are now subject to a standard corporation tax rate of 12.5 per cent on trading income, an increase on the preferential introductory IFSC rate of 10% offered in 1987 to support establishment of the centre, but a fiercely competitive rate that the Irish government has committed to maintaining.

The proposal for an IFSC was a radical new approach by the Industrial Development Authority and part of a broader project of urban renewal and redevelopment. Acknowledging the global slowdown in manufacturing, the IDA was focussed on alternative sources of investment into the economy. Using tax incentives as it had before it was suggesting the Republic of Ireland as a centre to operate a niche market where it could provide financial services not operational already or more competitive services than European counterparts. As one of least sheltered industries in the global economy,

investment companies, leasing companies, stockbrokers, treasury companies and other providers of financial services. Established in 1984, the association is a constituent part of IBEC.

⁹⁴ These data are available on-line provided by the Irish Banking Federation, in its *Banking Statistics*.

⁹⁵ For a good historical overview of the IFSC see materials prepared by Aidan Kane at National University of Ireland, Galway [available at <http://www.aidankane.net/archive/2000/ec301/ireland/students/mitchell/webp.htm>]

development of the international fund industry as one element of the IFSC activities would require the location and its operations to be extremely competitive internationally.

The notions of good and bad competition emerged as a source of much discussion in terms of the role of both the business and government sectors in supporting good competition and hindering the type of competition that devastated elements of the financial sector, its reputation and consumers' views of how the market economy worked. Porter⁹⁶ outlines the characteristics of a good competitor and several appear to not have applied to elements in business/commercial banking. For example, a good competitor understands the rules and in doing so aids market development, maintains realistic assumptions about the industry and its own relative position.

The importance of the maintenance in general of an environment where good competitors prevail was lost sight of in the latter years of the Celtic Tiger with responsibilities resting on government, regulators and businesses themselves.

As a particularly labour intensive activity (whether in retail or commercial arenas) the banking sector's attempts to enhance productivity have revolved around attempting to reduce staff numbers through increased and more intensive use of IT systems. Standard measures of productivity such as products sold per customer would logically rise with reduced staff complements and increasing reliance on systems. Yet as in the case of so much of the IT promise, the banking sector has failed to realise the returns from IT that it expected from its investments. With imitation rife across the retail banking sector and much networking and informal contacts serving as conduits for such information flows, it was argued by interviewees that little scope existed for sustainable and competitive - i.e. relative to competitive rivals, productivity improvement. Hence, benefits from IT-based productivity improvement were industry wide with benefits accruing to customers rather than the retail banking sector.

In terms of innovation in the sector, the sustained progress by Anglo Irish Bank into commercial banking in the mid to late 1990s might arguably have been deemed innovative and attributable to an ability to convert a relative weakness – more expensive credit terms – into a competitive strength through faster and more local

Anglo Irish Bank:

The bank was established in Dublin in 1964 and listed on the stock exchange in 1971. A series of more recent acquisitions generated growth and increased its national and international presence:-

1998 – acquired Irish Bank of Commerce

1995 – acquired Royal Trust Bank (Austria) a bank with a 100-year history, from Royal Bank of Canada and renamed it Anglo Irish Bank (Austria). Anglo Irish also acquired a loan portfolio from Allied Dunbar

1996 - acquired Ansbacher Bankers, which was established in Dublin in 1950

1998 – acquired Credit Lyonnais (Austria) and combined it with its existing Austrian operations

1999 – acquired Smurfit Paribas Bank, a joint-venture that Banque Paribas had helped establish in Dublin in 1983. Also bought loan portfolio from Bayerische Hypo und Vereinsbank

2001 – acquired Banque Marcuard Cook and Cie. In Geneva, renaming it Anglo Irish Bank (Suisse)

2008 – Following loans to-directors scandal, both Chairman and CEO resign

2009 – Nationalisation.

⁹⁶ Porter, M.E. (1985).

decision-making. Competence strengths of staff in offering bespoke solutions, and problem solving abilities would support this perspective. Subsequent revelations regarding alleged failures to adhere to guidelines and standard banking practices, however, would argue against such a conclusion. An alternative position was expressed that innovation opportunities were limited and that “Banking is a very simple business but when the bankers lose track of what it’s basically about and over complicate what’s happening in the markets it’s a recipe for disaster – stupid. Thankfully it’s now back to basics - business plans and projections.”

In discussions of innovation in banking, our interviewees both identified that a key issue revolves around how to generate quality. As they put it “with the right staff and systems to produce the best decision for the customer” and alternatively “better system process productivity”. In support of these views, Frei et.al. (1998: 35) point out that

“The alignment of technology, HRM, and capital investments with an appropriate production “technology” appears to be the key to efficiency in this [banking] industry. To achieve this alignment, banks need to invest in a cadre of “organizational architects” that are capable of integrating these varied pieces together to form a coherent structure. ... [S]everal leading financial services firms have realized the need for such talents and are investing heavily in senior managers from outside the industry (most notably, from manufacturing enterprises) to drive this alignment of technology, HRM, and strategy.”

They conclude that a similar imperative pertains to all service industries, which, like banks, must develop a new generation of management talent to play this role of architect, one who can blend technical knowledge with complex organizational design issues to drive innovation through their firms.

With respect to systemic innovation-supporting activities, while the remit of the Irish Banking Federation,⁹⁷ as the main representative body for the banking and financial services sector in the Republic of Ireland, includes supporting the development and growth of the banking sector in the Republic of Ireland, the impact of its activities might be seen more in its attempts to ensure the views of banks are

Bank of Scotland (Ireland):

Founded in 1965 as Equity Bank Limited, in the early ‘90s, it was purchased by and became a subsidiary of the Bank of Scotland, part of the Lloyds Banking Group. In 2001, the bank purchased ICC plc¹ (originally established to encourage investment in industry in 1933 as the *Industrial Credit Company*, later known as *Industrial Credit Corporation plc*) from the Irish State.

In 2004, the company took over the direct mortgage sales business from its parent company, and moved it to Dublin. In 2005, it took over the chain of retail outlets of the Electricity Supply Board and turned them into main street banks making the company the fourth-largest bank in the Republic of Ireland, with 46 branches in a fifteen-month period.

In 2006, the bank adopted a two-brand strategy, rebranding as Halifax for its retail business and retaining the Bank of Scotland name for its industrial/commercial customers. It competed with new-to-market products including personal current accounts paying competitive interest on credit balances and a Visa Debit card (the first for Irish customers).

⁹⁷ A member of both the European Banking Federation and the International Banking Federation.

taken into consideration in the shaping of relevant policies. On the ground its impact is mainly felt through networking opportunities at conferences and seminars (e.g. data protection and fraud).

Engagement with educational institutions was considered as most important in terms of graduate recruitment and research activities were not focal to activities. Most interactions with the Institute of Bankers, dedicated to the professional development of its members and offering a range of 'relevant and rigorous' educational courses were considered to be supporting skills-development and addressing CPD requirements, however, a gap in terms of development of 'soft skills' and using educational models focusing less on information downloading and more on transformative approaches was recommended.

Chemicals, Pharmaceuticals and Emerging Biotech

The Irish government's successful policy of attracting global pharmaceutical companies to the Republic is revealed by the fact that 16 of the top 20 global pharmaceutical companies have facilities in the Republic of Ireland.⁹⁸ The sector currently has almost 500 companies ranging from subsidiaries of global Chemicals/pharmaceutical companies (BASF, Pfizer, GSK, Wyeth etc) to smaller speciality Chemicals and plastics producers. Approximately 25,000 are employed in the Chemicals/ Pharmaceutical sector with a further 10,000 in the related industries of plastics and rubber.⁹⁹ It is estimated by PharmaChemical Ireland¹⁰⁰ that a further 24,000 jobs are dependent on delivering services to the sector.

The Republic of Ireland, as a small open economy, followed an Export-Platform Model for its development. Recent dominance of multinational companies' (MNC) activity in this and other sectors has been a feature of Irish economic life that can be traced back to abandoning a protectionist stance evident from the early 1960s and membership of the European Economic

IDA Ireland:

The IDA was founded in 1949 as the Industrial Development Authority and its initial focus was on stimulating, supporting and developing export-led business and enterprise. In 1994 following a government review the authority became the Industrial Development Agency (Ireland) or more commonly, IDA Ireland, with responsibility for the attraction and development of foreign direct investment in Ireland and development of indigenous enterprise was diverted to a separate entity, Enterprise Ireland.

Since 1994 IDA Ireland focuses exclusively on the promotion and development of high-quality foreign direct investment (FDI) in Ireland, in both manufacturing and international services sectors.

⁹⁸ This information is provided on-line by PharmaChemical Ireland an association of approximately 50 companies. PharmaChemical Ireland is a major sector within IBEC, the Irish Business and Employers Confederation.

⁹⁹ These statistics are taken from the annual *Census of Industrial Production*, Central Statistics Office, Ireland, 2007.

¹⁰⁰ PharmaChemical Ireland is the leading representative body for the pharmaceutical and chemical manufacturing sectors in Ireland. It is a major business association within the Irish Business and Employers Confederation (IBEC).

Community in 1973. While the receipt of more than €17bn in European Structural Funds undoubtedly contributed to economic (and social) development, access to a substantial and growing European market played a central role in subsequent economic activity, particularly for attracting MNCs. The Republic of Ireland managed to punch above its weight, attracting over 5% (in 2002) of FDI coming into the EU relative to its 1% share of the EU (15) population. The role played by the Industrial Development Authority (IDA) since its inception in 1949 has been central to the Republic of Ireland's development trajectory. Almost 1,000 companies operate today in the Irish Republic supported by the IDA with over 136,000 employees¹⁰¹ the majority (94,000) in US-owned companies.

One such company that we interviewed is GlaxoSmithKline that opened a manufacturing plant in Cork in 1975 and in 2009 had two manufacturing plants (in Waterford)¹⁰² had complemented its Cork manufacturing operations¹⁰³ with R&D and European Trading operations while its Sales and Marketing functions were also located in Dublin, employing 1,500 staff in total. It will invest a further €280m in investments supported by IDA Ireland creating up to 200 new high level positions. While the vast majority of output is focussed on international markets, it has established a research project into gastrointestinal diseases, in collaboration with Alimentary Pharmabiotic Centre (APC) in University College Cork. This project is jointly supported by IDA Ireland and Science Foundation Ireland (SFI) and involves an investment of up to €13.7m.¹⁰⁴

The Alimentary Pharmabiotic Centre (APC) is one of the Republic of Ireland's nine CSETs - Centres for Science, Engineering & Technology - established in 2003 to help link scientists and engineers in partnerships across academia and industry to address crucial research questions, foster the development of new and existing Irish-based technology companies, attract industry that could make an important contribution to the Republic of Ireland and its economy, and expand educational and career opportunities in the Republic of Ireland in science and engineering. CSETs must exhibit outstanding research quality, intellectual breadth, active collaboration, flexibility in responding to new research opportunities, and integration of research and education in the fields that SFI supports.

¹⁰¹ IDA Annual Report, 2008

¹⁰² Products include Panadol, Coldrex, Solpadeine and Panadol Extra.

¹⁰³ This is the sole production site for a number of the Group's top selling drugs such as Seroxat, an anti-depressant, Avandia which addresses Type 2 diabetes and Coreg which treats serious heart conditions.

¹⁰⁴ GlaxoSmithKline (GSK), with the support of IDA Ireland, is investing up to €14.6m in a collaboration with the Trinity College Institute of Neuroscience (TCIN) and NUI Galway, on an R&D programme for the discovery of new therapies to treat Alzheimer's Disease.

Science Foundation Ireland was established in 2000, modelled on the US National Science Fund, as a sub-board of Forfás, (the Republic of Ireland's national policy advisory body for enterprise and science) to administer the Republic of Ireland's Technology Foresight Fund (€646 million). It is described as the National Foundation for Excellence in Scientific Research and provides awards to support scientists and engineers working in the fields of science and engineering that underpin biotechnology, information and communications technology and sustainable energy and energy-efficient technologies development. SFI provides grants for researchers from around the world who wish to relocate to the Republic of Ireland and those already based in the Republic of Ireland, for outstanding investigators, for conferences and symposia, and for collaboration with industry. By mid 2008 it had allocated over €1.14bn in more than 2000 separate awards. The main funds allocated by SFI were for individual investigators (€427m), Centres for Science, Engineering & Technology (€165m) Research Frontiers Programmes (€136m) and Strategic Research Clusters (€90m).

The Manager of the APC offered insights into its activities. By 2009 it had a 120 member multidisciplinary research team – microbiologists, immunologists, food scientists, gastroenterologists, psychiatrists, pharmacologists – involving staff based at University College Cork and the Teagasc¹⁰⁵ Food Research Centre focused on improving understanding of the gastrointestinal tract and its microbial community. Effective liaison with industry is delivered through its two significant industry partners involved in the APC research activities, Alimentary Health Ltd., an Irish biotech company and GlaxoSmithKline in its efforts to expand its pharmaceutical base into biotechnology. They consider their research as truly collaborative evidenced by hosting four staff members embedded in the Centre funded by GSK and a further twelve funded jointly by GSK and the IDA. They focus on outputs of publications, licenses and patents but given the nature of the research, getting products to approval and market stage within a 10-year time frame is considered good.

Pressure internationally on pharmaceutical companies from generic products and the end of patents on many drugs with few blockbuster replacements has seen development into the area of biotechnology by many firms with ongoing impact for Irish operations under pressure to prove the potential for the ongoing contribution of their

Context for SFI:

In 1998, the Minister for Science, Technology and Commerce requested the Irish Council for Science, Technology and Innovation to undertake a Technology Foresight exercise to inform prioritisation of State investment in science and technology. The exercise concluded that biotechnology and ICT represent

“the engines of future growth in the global economy... A world class research capability in selected niches of these two enabling technologies is an essential foundation for future growth”.

This conclusion corresponds to the science-push innovation policy frameworks, in place across Europe where most of the funding for research from government is channelled through higher education institutes. It is hoped that the research will generate technological breakthroughs, new products, services and processes.

¹⁰⁵ The Irish Agriculture and Food Development Authority.

subsidiaries to HQ.¹⁰⁶ To date, however, the biotechnology sector and its product impact remains relatively small internationally with the US the major market. All of the main competitors in the sector have a presence in the Republic of Ireland including Wyeth, Pfizer (more focussed on pharma) GSK, Novartis, Eli Lilly and Johnson & Johnson. Developments in the pharma sector internationally are relevant to many companies in the lower harbour region of Cork where an agglomeration has developed. Few strong 'cluster' effects have emerged across these facilities as there has been little reported by way of meaningful collaborations generating general benefits for most/ all firms.

In addition to the benefits of the competitive corporation tax, the IDA identified strengths for the pharma sector to include:

- the Republic of Ireland's commitment to creating a base for global pharmaceutical R&D (argued by GSK to have played a role in its decision to invest €34 million in R&D)
- a bank of specialised highly skilled pharmaceutical professionals and technicians (the only 'cluster' type) benefit.
- Supply chain strengths in the form experience in pharmaceutical manufacturing and the supply of active ingredients and finished products
- the Republic of Ireland's commitment to the highest pharmaceutical manufacturing standards focussed on meeting and exceeding international criteria.

Discussions with representatives of MNCs in pharmaceutical and electronics sectors have supported this perspective although specific concern was raised about the low number of graduates from Electronic Engineering and its impact on electronics and ICT companies' futures. The role of Higher Educational Institutions was identified in discussions with Forfás staff as a key lever in the innovation policy arena that had proven successful.¹⁰⁷ The increased contribution of public funding to R&D in Higher Educational Institutions is clear, rising from 20 percent of the Republic of Ireland's gross expenditure in 1996 to 26 percent in 2006. Despite this increase, there remains a widely held concern that Irish R&D expenditure still lags by international standards.¹⁰⁸

Channels and sources for knowledge generation and sharing were identified at national level as the Irish Bio Industry Association and Enterprise Ireland's LifeScience and Food Commercialisation Group, also known as EIBio. European and US bio-organisations were also mentioned in terms of openness to new information and knowledge which was explained in the context of needs of a developing and emerging sector nationally and internationally. There are extensive efforts nationally and internationally to partner with other firms and research institutions as the sector attempts to strengthen its presence.

¹⁰⁶ This comment was raised by the IDA at a more general level in what it terms as the transformation agenda by which they meant the imperative for businesses to generate higher value activities and thus increase their strategic importance within their parent company. A survey conducted in 2005 by National Irish Bank and the Irish Management Institute found that half of all companies rated their Irish operation as either strategically important or very important in terms of their global operation but by 2008 this figure had increased to 66%.

¹⁰⁷ Interviews with staff at Forfás focussed both on recent work on the Health/LifeSciences sector as well as the broader issues of relevance to this Report.

¹⁰⁸ In 2006 gross expenditure on R&D was 1.56 percent of Irish GNP, compared to the EU 25 average of 1.77 percent.

Food – Distribution, Logistics and Processing

The Food and Drink sector forms a crucial part of the economy accounting for approximately 8% of total GDP and around 18% of total GVA in manufacturing, and 10% of total exports.¹⁰⁹ It is the single largest indigenous sector in the Republic of Ireland implying that a greater extent of the supply chain – raw materials, production and processing, logistics, sales and marketing, professional services and headquarters - is located in the Republic of Ireland. Total sales in 2008 amounted to almost €25bn. There are approximately 600 companies in the sector employing over 43,000 people. The sector takes virtually all the output of the Republic of Ireland's 120,000 farmers and taking into account distribution and retail, in total over 230,000 people are directly and indirectly dependent on the sector in the Republic of Ireland.¹¹⁰ On its own the industry was responsible for half of all purchase of Irish goods and services by manufacturing industry, indicative of how embedded it is in the economy. The sector's strengths are linked to the traditional areas of meat and dairy, responsible for 50% of exports from the sector, but increasingly prepared Foods have become an important sector now accounting for around half of total sales.

In terms of its linkages to international markets, the sector relies largely on European markets with almost half of exports (45% in 2008, of over €8bn) going to the UK while a further third of exports are destined for other European markets. While there are ongoing attempts at market diversification, the concentration of exports to the UK means exporting Irish firms are facing the increasing competitive pressure of exposure to the Euro-Sterling exchange rate on profit margins. Over a five year period, from 2003, the Euro-Sterling rate was in the region of £0.65 - £0.69. The subsequent two years have seen a steadily upward trend in the Euro-Sterling rate with consequences in terms of losing markets abroad, in not only the UK but in third markets in competition with UK companies, and jobs domestically. The sector accounts for over two-thirds of all exports by indigenous manufacturing companies. The Republic is the single largest supplier of Food to the UK and the biggest exporter of lamb to the EU. It also produces 15% of global output of infant formula milk.¹¹¹ The sector comprises Irish subsidiaries of global producers such as Unilever, Cadbury, Heinz, specialised manufacturers such as Nutricia, and large locally based companies including the Kerry Group.

The main challenges facing the sector relate to rising business costs and the appreciation of the Euro. Since 2000 electricity prices have increased by 77%, substantially in excess of output prices or 'factory gate' prices increases.¹¹² The gap between the Republic of Ireland and the EU 15 or UK costs for electricity are approximately 20% and while they too experienced increases since 2000, these were in the order of 47% in the UK

¹⁰⁹ For detailed information see *Food and Drink Industry in Ireland: Competitiveness Indicators 2009* published by IBEC, the Irish Business and Employers Confederation.

¹¹⁰ See the *Census of Industrial Production*, produced by the Central Statistics Office, Ireland.

¹¹¹ See An end-to-end strategy for the Irish Food and Drink sector Economic impact and policy challenges, a report commissioned by Food and Drink Industry Ireland, and published by IBEC, 2006. Wyeth Nutritional Ireland established in 1974 a facility which has become the largest purpose built infant nutritional production facility in the world.

¹¹² See The Food and Drink Industry in Ireland Closing the Gap: Competitiveness Indicators 2009, a report commissioned by Food and Drink Industry Ireland, published by IBEC, 2009.

and 36% in the EU. Concern has also been expressed with regard to waste charges relative to competitors. According to figures published by the Irish National Competitiveness Council, waste disposal costs per tonne in Dublin (in 2007) were €182, compared to €78 in Belfast, €70 in London and €57 in Manchester.

Such cost competitiveness issues were raised in interviews with staff and businesses dealing with the Irish Sea Fisheries Board (Bord Iascaigh Mhara) the agency with statutory responsibility for developing the Irish Sea Fishing and Aquaculture industries. The Republic of Ireland's first Seafood Development Centre - the first dedicated innovation facility for sector – opened in October 2009 and both companies in the sector and agency representatives admitted the sector has, to date, under-achieved in terms of exploiting and maximising market potential for Irish seafood beyond the primary output, 80% of which is destined, unprocessed, for markets of Spain, France and Germany. The broad fishing industry consists of 220 processors, 200 large fish boats, 3000 small boats and around 250 aquaculture farms. Over 90% of fish processed in the Republic of Ireland was imported due to both quality consistency and price issues. The goal of the Centre is to foster and integrate innovation into feasible business strategies and the development of new products and processes for the seafood industry. With an overall space of 768 m² its facilities include a Wet Fish Area focusing on processing, a Graduate Area where up to 12 graduate students will be available to work on Centre projects - improving their experience of a working seafood-related business and research environment, a product development kitchen and two business incubation units to support new or already established business in their development phases.

Business Expenditure on R&D (BERD) for the food and drink sector was €64 million in 2005, a 12% increase over 2003. This equates to 0.35% of output and compares well with the EU 15 average of 0.24%. The fourth Forfás *Community Innovation Survey* indicated that 80% of firms in the food, drink and tobacco sector were engaged in innovation activity. The regional distribution of BERD also reflects that of the food and drink sector with a strong regional spread, and particular concentration in the south and east of the country. There were 1,085 research personnel (researchers, technicians and support staff) working in the food and drink sector in 2005, an increase of 58% over 2003.¹¹³ These staff may be categorised as engaged in Basic Research, 13.7%, Applied Research 29.4% and Experimental Research 56.9%.

¹¹³ See Research & Development Performance in the Business Sector Ireland 2005/6, Forfás 2007.

More than €5.9 billion will be spent on science, technology and innovation over the course of the Republic of Ireland's National Development Plan (2007 – 2013).¹¹⁴ From this funding, €641m (11%) is allocated to the Agri-Food Research Programme. Forfás measures Government-funded R&D (GOVERD), which shows that despite significant investment, the Republic of Ireland remains below EU 25 and OECD levels (by *more than 50%*).

From an end-consumer perspective, the Republic of Ireland has one of the highest levels of grocery retail sector concentration in Europe, at 70.5% for the top three retailers, surpassed only by the Nordic countries and Switzerland. To address potential imbalances this may cause, the representative agency for the Republic of Ireland has called for the introduction of legislation to bring about responsible trading practices between grocery retailers and their suppliers, an ombudsman to investigate complaints of irregular commercial practices or abuse of power, and abandoning the practice of forcing suppliers to pay for advertising, display of goods or 'hello money' unless there is a clear benefit to both parties.

In our discussions with Allied Foods a leading player in the Irish chilled and frozen food distribution market with substantial operations based in both Dublin and Cork we were offered insights into a business forced to deal with substantial changes in its competitive environment in its twenty years in business. While its focus is mainly on food wholesale and food distribution its competitive advantage increasingly lies in the logistics solutions it can offer in conjunction with its food business and separately to that business. In terms of driving firm competitiveness, we were informed that "income follows cost reductions" and that the bigger players and customers maintained several partners to reduce any incentives for lock-in or pressure on value appropriation. For such businesses, productivity change is intrinsically related to the efficiency of the supply chain and to the metric 'cost per case'.

Allied Foods

Allied Foods is a member of the DCC Food and Beverage division of DCC plc. It is the number one frozen food distributor in Ireland, with a developing chilled business. It offers a full range of supply chain solutions (procurement, brand management, warehousing and distribution), to major retailers, manufacturers and food service customers. Its subsidiary, Allied Logistics, is the leading temperature controlled logistics provider to some of the largest food retailers and suppliers in Ireland.

DCC first invested in Allied Foods in 1989 and has owned 50% of the voting share capital and 51.5% of the total share capital of Allied Foods' holding company, Millais Investments Limited, since 1998. In 2004 it acquired the remaining 50% of the voting share capital and 48.5% of the total share capital (for €14.5m - a multiple of 8.5 times operating profits).

Its assets include a temperature controlled distribution facility of 155,000 square feet on a 10 acre site in Dublin and a temperature controlled distribution facility of 30,000 square feet on a three acre site near Cork city.

In the ten years to 2009, DCC Food & Beverage has achieved a compound annual growth rate of 7.1% in operating profit.

At the macro level efficiencies have entered the sector with the move away from small-scale wholesaling activities towards central distribution centres (CDCs), allowing for cost reductions through up-scaling. Upgrading road infrastructure between the main Irish cities of Dublin and Cork was identified as a crucial ingredient for increasing efficiency of

¹¹⁴ This is available at <http://www.socialinclusion.ie/documents/NationalDevelopmentPlan2007-2013.pdf>

CDCs generally and for Allied Foods in particular. For wholesaling businesses themselves, cases are organised for customers and delivered by the wholesaler. Selecting the items required for customer cases is the 'picking cost' and it is the most labour-intensive and costly activity in the warehouse. Some cost can be saved by minimizing the travel distances through allocation of most popular items near input/output point in the warehouse and slotting related stock keeping units together. Improving the process of picking, is therefore a means for efficiency and productivity improvement. The picking cost is negotiated with Trades Unions which creates issues around flexibility and with competition in this segment from the UK relative wage rates as well as the exchange rate differential exert significant pressure on profits.

Similar to the retail banking sector, much of the innovation conduits was argued to relate to IT systems, eg warehouse management systems and how these are implemented. More basically it was also stated that getting costs out with smarter ideas was innovation for wholesaling, for example new ways of picking out of central boxes rather than boxes 'owned' by specific customers was a productivity enhancing change in business practice.

Sources of formal learning were available externally primarily through the National Institute for Transport & Logistics (NITL)¹¹⁵. It claims to create a fundamental resource for logistics and sustainable transport efficiency in the Republic of Ireland, a claim supported in our company interviews where it was argued that the NITL offered their most useful and applicable source of updates and new information for logistics purposes, appropriate to international best practice, which was the organisational focus. Logistics conferences in terms of the formal knowledge transfer and also informal networking was identified as a source of relevant business information while the tendering process, even where the business was unsuccessful was acknowledged as a valuable source of informal learning. Foreign workers were also identified as bringing new and useful knowledge to bear on business practices while information from customers, particularly the larger players was considered central to the company's ability to provide requisite services to meet customers' requirements. Little knowledge sharing was identified to formally occur between logistics companies.

Findings

Achievements to date in attracting MNCs with their substantial flows of expertise, capital and links to international markets coupled with human capital available in the Republic of Ireland has improved the productive capacity of the Irish economy. The stage has been reached where greater attention towards innovation is required to move beyond the manufacturing orientation on which recent success was founded. Changing the focus of value-added activities of multinational businesses from manufacturing to more innovation-intensive activities is supported through the active interventions of IDA through its network of client companies. Companies are aware of these supports and to date local networks

¹¹⁵ The NITL is supported by the National Development Plan through Enterprise Ireland and is managed by the Department of Transport Engineering at Dublin Institute of Technology.

with educational institutions and other companies for research purposes have taken place through business academic collaborations by for example, Cisco, Analog Devices, Aon (financial services) and Helsinn (pharma) and Intel with universities on single and joint projects. The challenge for local subsidiaries of such companies is to strengthen the performance of local plants when compared across their international subsidiary networks and the innovation imperative is thus driven both by competition from markets and from other subsidiaries. Successes such as GSK's expansion and the wins referred to above indicate that a focus on increasing innovation intensive supports can and does generate the required benefits.

Evolution and integration in policy focus to support a changing economy is required not only in the context of the MNC sector but for indigenous companies also. Such evolution is evident in, for example, a competitiveness fund offered by Enterprise Ireland for 2003/4 while a focus more on Productivity was evident in 2006/2007 with the organisation by Forfas of focus groups and a conference on Irish productivity followed by the publication of Perspectives on Productivity. The current policy focus towards R&D and innovation is articulated clearly and implemented across the agencies we interviewed. In the case of Enterprise Ireland, their application of an 'ultimate metric' of export success - maintenance of export shares and further penetration of export markets – also points to the market focus and discipline they consider the key guides for domestic firms lacking a local competitive context due to limited market size. In terms of its expenditure, *Enterprise Ireland* ranked R&D programmes (both in-company and collaborative) second relative to supports provided through their High Potential Start Ups (HPSU) Programme. While 70 start-ups are funded annually, and supported through incubation centres opened in the last 4 years administered through Institutes of Technology, the EI board would like to increase the start-up target numbers. EI, however is satisfied to be in a position to identify at least 70 quality projects deserving of funding. HPSUs must have a real likelihood of reaching sales of €1m in 3 years with long-term potential, and are beyond the scale and profile of micro-companies that are supported through County Enterprise Board structures.

Despite its central role in much of the Strategic Policy Intelligence conducted by and on behalf of government, the concept of clustering (first identified as a strategic policy goal for the Republic of Ireland in 1992, in the 'Culliton' Report)¹¹⁶ or rather its economic impact has not been widely visible across the economy. Although it is argued that clustering has occurred,¹¹⁷ rather there is evidence of successful agglomeration¹¹⁸ as shown in Figure 5.

¹¹⁶ J. Culliton, Report of the Industrial Policy Review Group - A Time for Change: Industrial Policy for the 1990s; Stationery Office; Dublin; 1992.

¹¹⁷ Such as the Report from the <http://www.entemp.ie/trade/euaffairs/Knowledgeandenterprisecusters.pdf>

¹¹⁸ Designated as significant geographical congregations in the Knowledge and Enterprise Clusters Report above.

Figure 5: Republic of Ireland - Location of Business Agglomerations



It appears that the current Strategy on Science and Technology, of which all agencies are not only aware but actively working towards (directing particular attention to areas of ICT, biotechnology and sustainable energy) would be superfluous to requirements had the goals of cluster policy been reached i.e.

- Close linkages between industry and higher education;
- Effective knowledge flows between suppliers and customers; and
- Collaborative, focused attention to common problems.

The above goals remain as targets to be addressed through implementation of cluster policies and would go some way to addressing remaining and significant weaknesses in the innovation system and would address needs of both MNC and indigenous firms if organised through cluster support networks.

More generally, the recent downward productivity trend should not be interpreted as the result of the current economic climate and more worrying from the longer-term

perspective is the observation that the boom period was not associated with any change to the trend growth of labour productivity. Government-funded R&D (GOVERD), which shows that despite significant investment, the Republic of Ireland remains below EU 25 and OECD levels (by *more than* 50%). The Republic of Ireland's current unemployment rate of 12.5% ¹¹⁹ represents a rise from 6.4% in 2008 and the perceived natural rate of 4.4% prevailing between 2005 and 2007.

Relatively high unemployment has characterised the economy historically, into the middle phase of the so-called Celtic Tiger era remaining in double figures until 1998. This complicates the policy orientation, articulated and shared across the agencies we dealt with, since focusing on boosting employment requires, arguably, both complementary and alternative approaches and may relegate productivity, competitiveness and innovation concerns to lower priority as immediate needs challenge medium and longer term imperatives.

¹¹⁹ This is the seasonally adjusted standardised unemployment rate (SUR) reported by the Irish Central Statistics Office, in December 2009.

5. Conclusions and Further Discussion

The countries at the focus of this Report are amongst the richest and most economically developed in the world. Their economic strategies vary substantially from the government directed approach practised in Singapore to the more market-guided approaches of New Zealand, and to a lesser extent, the Republic of Ireland. The SOE status of these countries create barriers to development not experienced by larger nations but despite this potential brake on progress each exhibits an array of foundations for competitiveness, productivity and innovation. Given our consideration of the economies competitiveness profiles and innovation performances in the context of analysis of advanced economies we offer concluding comments in this section. We also highlight our Policy Insights from our field interviews by way of the issues that are to be kept in mind for the final phase of our study when the focus turns specifically to the context of the competitiveness, productivity and innovation environment of Northern Ireland.

5.1 *Competitiveness and Innovation*

In the context of the extensive range of research attempting to explain sources and processes of economic growth, and taking into account the analysis throughout this Report, it is clear that the economic trajectories leading to well-functioning productive modern economies are varied. Disparate and country-case specific policy approaches, economic structures and the myriad reactions to incentives created by these institutions for business growth and development generate the outcomes observed in competitiveness, productivity and innovation.

The competitiveness profiles in Section 2 generated from hard data and survey responses offer a comprehensive perspective on each country in terms of its environment for supporting further economic development. If all was equal across countries in terms of Basic Requirements and Efficiency Enhancers, the task of identifying obstacles to growth would fall to a focus on Innovation and Sophistication factors. From the investigation of relative weaknesses in this category, a check-list for changes required for business strategies and government policy may be devised.

Of particular note is that for both Singapore and New Zealand, their weakest performance is observed for the Innovation and Sophistication category. To address gaps requires some fundamental adjustment to business competition in New Zealand that supports a move towards more niche-type strategies where premium products and services, are the object of more and more firms. Over focus on low-end products limits the capacity for improvement. In terms of innovation, although its scientific and research institutions rank highly, limited availability of scientists and engineers hinders innovation while the government does not act as a sufficiently sophisticated and demanding purchaser of advanced technological products to drive local businesses. Singapore performs relatively better on Innovation than Business Sophistication, corresponding to the commanding role played by the government evident from our examination of its business environment.

While successful in creating an attractive environment for attracting research scientists and supporting this element of the innovation system, government agencies may inadvertently have created barriers to the creativity and approach to risk-taking required for greater commercialisation of discoveries. The Republic of Ireland's relatively stronger performance in Business Sophistication is surely linked to the pervasive role of MNCs in the economy, to their increasing but as yet limited R&D activities, and their strategies built on understanding and delivering to international demand. However, the capacity for innovation is limited as perceived by survey respondents and the role played by government in procuring technologically advanced products (as one example) does not create a demanding customer domestically creating incentives for further technological improvement.

Any assumption that a level playing exists in terms of our SOEs' achievements in Basic Requirements and Efficiency Enhancers is belied in the rankings generated and quite varied elements in the national policy trajectories that have resulted in each economy's National Innovative System are evident. Given the important impact that Efficiency Enhancers have in the rankings (and their strong association with GDP/capita performance) they are important facilitating features that support innovation practices and policies. This is achieved through human capital development and policy orientation resulting in effective and efficient markets for labour, capital and goods. Together these combine to support the capacity of local businesses (whether locally or foreign owned) to absorb new knowledge and technologies and ultimately apply it for productive purpose, irrespective of sector or industry orientation.

Where more basic factors such as infrastructure - in the cases of both New Zealand and the Republic of Ireland - are identified as barriers to productivity growth and competitiveness, their impact in terms of both the ability of firms to efficiently deliver goods and services to market and as barriers to innovation and the adoption of advanced business practices generate economy-side inhibitions to economic development.

Applying a similar approach to survey responses from business executives in Northern Ireland permitting us, albeit on the basis of one year's data, in our Final Report to rank Northern Ireland and consider its relative strengths and weaknesses following the same methodology facilitating comparison.

Our econometric analysis allows us to compare the appropriateness of alternative models of the determinants of patenting activities. We conduct this exercise across a panel of countries so as to generate results representative of a broad range of developed modern economies, and to allow disaggregation of our broad sample into small open and larger economies facilitating examination of whether SOEs are different when it comes to innovation. Our results support other research in finding path dependency in innovation - that countries with a successful history of patenting activity are likely to generate further patents. Clearly, however, as the case of Singapore illustrates, it is possible to buck this general trend and rapidly accumulate patents even from a low historical level. Increasing patent stock by 10%, generates a 2% increase in patents revealing the extent to which the relationship holds. The relative difficulty for SOEs in generating patents was indicated by a

50% greater coefficient in absolute terms (measured as negative) on the constant term than for the full sample.

We find that R&D spending is the most significant determining factor for patenting activity with greater impact than a country's initial patent stock in explaining further innovation activity. A 10% increase in R&D spending is found to result in a 6.7% and 7.5% for SOEs, approximately 40% higher than the impact measured for the full sample. An increase of 10% in the level of Property Protection was found to result in over 3% increase in patenting activity for our SOEs, over 200% greater than the impact on our full sample. For improved *Openness*, we find a 50% greater impact on patent production in SOE's at over 2%, relative to the average sample.

Improving on macroeconomic variables such as total R&D expenditure or levels of private property protection and openness are associated with greater patenting activity, particularly in the latter two of our small open economies pointing to the broad-policy supports that impact on patenting activity. There was no support for the role of clusters and interaction given our selected variables, which given the information gleaned from our country-analyses raises questions about the quality of the measures used and points to the benefit in the complementary macro, micro and case-based approach followed. If there is an unequivocal finding from our interviews with business and policy actors in each economy it is that information and knowledge sharing across businesses, with support agencies and research institutions supports innovative practices and strategies. Examination of the competitive and innovation context beyond the hard data also permits analysis of those innovative activities that generated market successes rather than solely a patent output.

Finally, it is worth noting that notwithstanding the analysis of innovative activity (in line with related research) conducted for this Report, clearly innovation that matters for productivity and competitiveness improvement is essentially a business phenomenon, not solely a scientific one. The knowledge needed for business innovation is not necessarily, or even frequently, scientific knowledge. Rather it is knowledge of the market place. More than one model of innovation exists and where policy is based on a framework that focuses on or favours one source, it may achieve limited or partial success. Given the significant budgets involved, in the context of current economic difficulties, maximising the impact of policy needs to be considered. The general imperatives for modern developed economies focusing on enhancing their innovative capacity is to put in place incentives for firms (including subsidiaries of MNCs) to innovate locally, to incorporate high-skilled workers, from whatever source, to exploit opportunities afforded by the digital economy for information inflows and outflows, to support institutions that are critical to innovation and ensure regulations and other government policies support, rather than retard, innovation.

5.2 Insights from Field Research

Each of our case analyses, New Zealand, Singapore and the Republic of Ireland, offer a series of lessons relevant of the development of policies to foster productivity, innovation and competitiveness in small open economies. These insights are organized by country around four major themes of Macro-economic Foundations, Target Strategies,

Organizational Design and Governance and Evaluation. We have identified these themes as an appropriate organising framework for approaching our Final Report addressing the key features at the heart of working towards delivering on goals of enhancing productivity, innovation and competitiveness. These themes will feature in our deliberations and analysis of the Northern Ireland case as we conduct the final phase of field research.

New Zealand

Macro-economic foundations

Market liberalization is a necessary but not sufficient condition for county success in globalized competition. Faced with a long-run decline in productivity and income per capita relative to other developed benchmark countries, New Zealand embarked two decades ago on major economic reforms, including privatization and opening up of markets. However, there is now an increasing realization that additional innovation system and governance elements are also needed to turn around productivity and competitive performance. These include investments in key components of the innovation system (see next point), active public-private sector engagement in developing policies and strategies, actions to support access to finance for enterprise, and efforts to encourage knowledge exchange, networks, and linkages internationally as well as domestically.

Investments in human capital, R&D, and infrastructure are critical in building the foundation for high-value economic growth. While the human capital base in New Zealand is strong, aided by inward migration, high-value economic growth and innovation has been limited by weaknesses in R&D investment and infrastructure.

Targeted strategies

Primary and food-processing sectors can have significant potential for innovation and export-led growth. The opportunities presented by primary and food processing sectors have not been overlooked in New Zealand, although in recent years increased attention has been targeted to fostering high-value growth in both products and services. R&D for primary and food-sector innovation is most-well developed in New Zealand, and the mechanisms to fund, identify and disseminate research targets appear to be effective.

Small economies can achieve success in emerging high-technology sectors through well-focused targeting of resources. For example, New Zealand has sensibly targeted biotechnology growth efforts in sectors and niches where it has some comparative advantage such as agri-bio and plant-bio. In other high-technology areas, niche software development (for example, in health IT or graphics) and advanced medical devices are among other select areas where New Zealand seems able to build and deploy private and public-sector capabilities which are competitive globally.

The encouragement of global-local strategies in public as well as private sectors is an important aspect of innovation strategy in a small open economy. A limited domestic market means that New Zealand companies must address international markets to grow.

The most successful private companies typically adopt global-local strategies, for example strategically allocating R&D and product development at home and abroad, and developing international linkages based on organizational proximity. Similarly, New Zealand's most successful universities have pursued internationalization strategies and seek to attract international students (e.g. international doctoral students pay home fees) and research activities. Government and quasi-government agencies have an outward orientation.

Organizational design

Redesign in the role and function of research institutes is a critical ingredient in innovation-led development. Privatization of public research functions does not necessarily guarantee success. Indeed, the separation of policy, contracting, and research implementation functions in New Zealand imposes high transaction costs. Where research institutes, including those of universities, are most effective in fostering innovation, including in the primary sector and in key high-technology sectors, common factors appear to be organizational reform, leadership, the development of tighter linkages between researchers and industry, and specific initiatives to disseminate results.

Well-designed innovation initiatives can reach traditional manufacturing sectors and induce significant spillovers. The offer of significant "free" R&D services through Industrial Research Ltd's "What's Your Problem New Zealand" programme attracted significant interest from companies throughout the country, improved the visibility of this Crown Research Institute, and leveraged new projects and interactions with companies.

Governance and evaluation

New Zealand's **open and transparent governance, and government's broad orientation to learning** and evaluation, are important aids in the effective development and improvement of competitiveness and innovation policies.

Active public-private exchange is important in developing strategies for targeted sectors. New Zealand appears to make effective use of non-profit organizations and associations to facilitate exchange and networking between private sector representatives and policymakers. Examples include Plastics New Zealand and NZBio, an association active in national and regional networking in the bio and life sciences sector.

Singapore

Macro-economic foundations

Investments in infrastructure and education over a prolonged period, supplemented by the influx of foreign talents, are critical to economic growth. While the human capital base and education system in Singapore is strong and developed over the last three to four decades, Singapore has promoted and achieved both significant inward migration and foreign direct investments. There has been consistent creation of superior infrastructure, by the JTC and the URA. The latest attempt is the investment and creation of

R&D Framework – big bang 2006-2010 after 15 years investment - to supplement the eco-system in Singapore.

In exploring a new economic model, learning and un-learning may be required.

There is a need to learn how to manage the nation's intangible assets, i.e. the idiosyncratic sentiments of its people and foreign talents.

Targeted strategies

EDB supports FDI and the needs of high tech clusters, whilst SPRING improves productivity, standards and innovation in domestic sectors. The two agencies are aligned in a total value creation approach and organised according to key clusters. Support is given to potential winners from domestic and foreign businesses including training (e.g. employee skills), technology enhancement (e.g. product development, IT grants) and management skills (e.g. intellectual property protection, internationalisation) to improve productivity, innovation and competitiveness.

FDI and export-oriented growth is strengthened by internationalization of domestic firms. Former Trade Development Board, rebranded as International Enterprises Singapore, also encourages and provides support to high potential domestic firms in outwards investments. IE targets markets afar as 7 hours flight distance from Singapore.

Organizational design

Well designed innovation and spill-over initiatives are core to policy implementation. National investment in the R&D framework has strong cross fertilization elements (e.g. GET-Up scheme of seconding 102 researchers into 69 SMEs). Research laboratories staff are encouraged and supported to leave and create spin-off firms (Curiox Biosystems).

The government and its agencies operate like a business in their thinking and approach. Agencies under MTI meet monthly; most public sector entities followed closely 5-year strategic plan that is aligned with the ERC strategic plans.

Strategies driven from the top can work, with participation from key business partners (ERC Committee). Feedback is sought from investors and businesses to identify new sources of industrial growth, and fed back to central government.

Governance and evaluation

Closed governance with meritocratic system of talent selection and pipeline development is central to the Administrative Services. Top civil servants are selected to head and move around key ministries and agencies.

Strategies and projects focus on finding “the next big thing”; many successes and some failures result but the small size of the country enable fine-tuning of focus and agile strategies to ensure winners are identified and losers quickly sieved out.

Republic of Ireland

Macro-economic foundations

Success in attracting FDI creates new growth and innovation opportunities for outward oriented companies. General restructuring of the economy that followed the embracing of an outward focus led to the destruction of many uncompetitive businesses as well as creating the export platform potential that attracted major international players to trade successfully out of the Republic of Ireland. Changing the focus of value-added activities of businesses from manufacturing to more innovation-intensive is to be supported through active collaborations.

Evolution and integration in policy focus to support a changing economy is required. Such evolution is evident in for example, a competitiveness fund offered by Enterprise Ireland for 2003/4 while a focus more on Productivity was evident in 2006/2007 with the organisation by Forfás of focus groups and a conference on Irish productivity followed by the publication of *Perspectives on Productivity*. The current policy focus is directed clearly towards R&D and innovation.

Targeted strategies

Internationally competitive MNCs generate both direct and indirect economic benefits. The attraction of key players in sectors including pharmaceuticals, electronics, and ICT through agencies such as the IDA has played an important indirect role in generating incentives for further business development. Development in logistics, supply chain services and in retail banking have generated sectoral and broader economy benefits forcing innovation from businesses in competitive environments.

The challenges for domestic businesses in an Export-Platform economy can be addressed with policy supports. Application of an 'ultimate metric' of export success - maintenance of export shares and further penetration of export markets - gives market focus and discipline to domestic firms lacking the local competitive context due to limited market size. In terms of its expenditure, *Enterprise Ireland* ranked R&D programmes (both in-company and collaborative) second relative to supports provided through their High Potential Start Ups (HPSU) Programme.¹²⁰

Innovation goes beyond Science. In Irish policy and Strategic Policy Intelligence documentation, innovation has been treated largely as a scientific concept, (following a lead from Europe).¹²¹ The predominant mindset sees competitiveness and economic growth as a

¹²⁰ While 70 start-ups are funded annually, the EI board would like to increase the target, but are happy to be able to identify at least that number of quality projects deserving of funding. HPSUs must have a real likelihood of reaching sales of €1m in 3 years with long-term potential, and are beyond the scale and profile of micro-companies that are supported through County Enterprise Board structures. The avoidance of deadweight losses through policy interventions was discussed and it was argued that the potential for such, while always possible, was less likely in the case of R&D policies rather than direct grants or similar supports.

¹²¹ For example, the European Commission has developed a strategy on Science, Technology and Innovation [http://ec.europa.eu/invest-in-research/monitoring/statistical01_en.htm], the UK government has issued a Science and Innovation Investment Framework [http://www.hm-treasury.gov.uk/spending_sr04_science.htm],

function of investment in leading-edge science and technology. That innovation relies as much on input from, and funding for, entrepreneurs, salespeople, managers and consumers¹²² needs to be embedded more explicitly into policy. Reliance on high-technology or scientific breakthroughs as the basis of innovation ignores the fact that many successful innovations (from a commercial perspective) were either not technologically based or relied on non-proprietary technologies. Rather they correspond to a market-pull view of innovation.¹²³

Organizational design

Effective roll-out of **technology transfer functions from universities takes time to implement** and to become an embedded feature of the economy - and is still in process. The importance of developing this function of higher educational institutions is particularly necessary when they are such central players in the generation of scientific publications and research. To support delivery of the technology transfer mission may require greater financial and strategic flexibility to be granted to educational institutions to meaningfully shift to a more business-driven agenda.

Engagement and implementation of 'cluster' type policies result in impacts extending beyond agglomeration. The contribution of clusters to the innovation imperative arises due to the support they provide for greater collaboration (e.g. suppliers, customers, education and research institutes) and focused attention on shared competitiveness problems. Innovative thinking on the relevant implications of clusters for SOEs, incorporating perhaps greater international collaborations, is also required.

Governance and evaluation

Consistent and ongoing evaluation of programmes underpins the selection of interventions for support, in the context of effectiveness in achieving goals set and value for money criteria. Openness in sharing results generated through evaluation processes indicates confidence of agencies in sharing learning, where appropriate.

Analysis of the **broad policy orientation and its impact should be based on well-specified criteria**, (eg cluster versus agglomeration) to maintain focus on ongoing challenges to enhancing collaboration and co-operation across the innovation system.

Ultimately innovation that generates economically viable products, processes and new businesses goes beyond the high-tech definition. Clearly, an important signalling effect is generated internationally by strong R&D, patent and publication performance in 'high-tech' sectors.

the Danish government has a Minister for Science, Technology and Innovation [<http://en.vtu.dk/>] and Ireland has published a similarly titled strategy [<http://www.entemp.ie/science/technology/sciencestrategy.htm>].

¹²² Bhidé, A. (2008) .

¹²³ For more on this argument see Jordan (2009).

Appendix

Appendix A: Structure of the Global Competitiveness Index 2009–2010

This appendix presents the structure of the Global Competitiveness Index 2009–2010 (GCI).

The numbering of the variables matches the numbering of the Data Tables. The number preceding the period indicates to which pillar the variable belongs (e.g., variable 1.01 belongs to the 1st pillar, and variable 12.04 belongs to the 12th pillar).

The hard data indicators used in the GCI are normalized on a 1-to-7 scale in order to align them with the Executive Opinion Survey's results.^a The Technical Notes and Sources at the end of this *Report* provide detailed information on all the hard data indicators.

Those variables that are followed by the symbol ^{1/2} enter the GCI in two different places. In order to avoid double counting, we give them a half-weight in each place by dividing their value by 2 when computing the aggregate score for the two categories in which they appear.^b

The percentage next to each category represents this category's weight within its immediate parent category. The computation of the GCI is based on successive aggregations of scores, from the variable level (i.e., the lowest level) all the way up to the overall GCI score (i.e., the highest level), using the weights reported below. For example, the score a country achieves in the 9th pillar accounts for 17 percent of this country's score in the *Efficiency enhancers* subindex. Similarly, the score achieved on the subpillar *Networks and supporting industries* accounts for 50 percent of the score of the 11th pillar. Reported percentages are rounded to the nearest integer, but exact figures are used in the calculation of the GCI.

Unlike for the lower levels of aggregation, the weight put on each of the three subindexes (Basic requirements, Efficiency enhancers, and Innovation and sophistication factors) is not fixed. It depends on each country's stage of development, as discussed in the text.^c For instance, in the case of Dominican Republic—a country in the second stage of development—the score in the *Basic requirements* subindex accounts for 40 percent of its overall GCI score, while it represents just 20 percent of the overall GCI score of Australia, a country in the third stage of development.

Finally, note that this year the structure of the GCI has undergone two minor changes. Variable 1.09 on the efficiency of the legal framework has been split into two distinct variables. Variables 1.09 and 1.10 now measure the degree of efficiency of the legal framework in settling disputes (1.09) and in challenging regulations (1.10). The second alteration to the structure is the exclusion of the measure of non-wage labor costs (formerly variable 7.03). The variables that belong to the two pillars affected by these changes (i.e., 1st and 7th pillars) were renumbered accordingly.

Weight (%) within
immediate parent category

BASIC REQUIREMENTS

1st pillar: Institutions.....25%

A. Public institutions.....75%

1. Property rights20%

- 1.01 Property rights
- 1.02 Intellectual property protection ^{1/2}

2. Ethics and corruption.....20%

- 1.03 Diversion of public funds
- 1.04 Public trust of politicians

3. Undue influence.....20%

- 1.05 Judicial independence
- 1.06 Favoritism in decisions of government officials

4. Government inefficiency.....20%

- 1.07 Wastefulness of government spending
- 1.08 Burden of government regulation
- 1.09 Efficiency of legal framework in settling disputes
- 1.10 Efficiency of legal framework in challenging regulations
- 1.11 Transparency of government policymaking

5. Security.....20%

- 1.12 Business costs of terrorism
- 1.13 Business costs of crime and violence
- 1.14 Organized crime
- 1.15 Reliability of police services

B. Private institutions.....25%

1. Corporate ethics50%

- 1.16 Ethical behavior of firms

2. Accountability.....50%

- 1.17 Strength of auditing and reporting standards
- 1.18 Efficacy of corporate boards
- 1.19 Protection of minority shareholders' interests

2nd pillar: Infrastructure.....25%

A. General infrastructure.....50%

- 2.01 Quality of overall infrastructure

B. Specific infrastructure.....50%

- 2.02 Quality of roads
- 2.03 Quality of railroad infrastructure
- 2.04 Quality of port infrastructure
- 2.05 Quality of air transport infrastructure
- 2.06 Available seat kilometers (hard data)
- 2.07 Quality of electricity supply
- 2.08 Telephone lines (hard data)

3rd pillar: Macroeconomic stability.....25%

- 3.01 Government budget balance (hard data)
- 3.02 National savings rate (hard data)
- 3.03 Inflation (hard data)^d
- 3.04 Interest rate spread (hard data)
- 3.05 Government debt (hard data)

(Cont'd.)

Appendix A: Structure of the Global Competitiveness Index 2009–2010 (cont'd.)

4th pillar: Health and primary education25%

A. Health50%

- 4.01 Business impact of malaria^a
- 4.02 Malaria incidence (hard data)^a
- 4.03 Business impact of tuberculosis^a
- 4.04 Tuberculosis incidence (hard data)^a
- 4.05 Business impact of HIV/AIDS^a
- 4.06 HIV prevalence (hard data)
- 4.07 Infant mortality (hard data)
- 4.08 Life expectancy (hard data)

B. Primary education50%

- 4.09 Quality of primary education
- 4.10 Primary enrollment (hard data)
- 4.11 Education expenditure (hard data)^{1/2}

EFFICIENCY ENHANCERS

5th pillar: Higher education and training17%

A. Quantity of education33%

- 5.01 Secondary enrollment (hard data)
- 5.02 Tertiary enrollment (hard data)
- 4.11 Education expenditure (hard data)^{1/2}

B. Quality of education33%

- 5.03 Quality of the educational system
- 5.04 Quality of math and science education
- 5.05 Quality of management schools
- 5.06 Internet access in schools

C. On-the-job training33%

- 5.07 Local availability of specialized research and training services
- 5.08 Extent of staff training

6th pillar: Goods market efficiency17%

A. Competition67%

1. Domestic competitionvariable^f

- 6.01 Intensity of local competition
- 6.02 Extent of market dominance
- 6.03 Effectiveness of anti-monopoly policy
- 6.04 Extent and effect of taxation^{1/2}
- 6.05 Total tax rate (hard data)^{1/2}
- 6.06 Number of procedures required to start a business (hard data)^g
- 6.07 Time required to start a business (hard data)^g
- 6.08 Agricultural policy costs

2. Foreign competitionvariable^f

- 6.09 Prevalence of trade barriers
- 6.10 Tariff barriers (hard data)
- 6.11 Prevalence of foreign ownership
- 6.12 Business impact of rules on FDI
- 6.13 Burden of customs procedures
- 10.04 Imports as a percentage of GDP (hard data)

B. Quality of demand conditions33%

- 6.14 Degree of customer orientation
- 6.15 Buyer sophistication

7th pillar: Labor market efficiency17%

A. Flexibility50%

- 7.01 Cooperation in labor-employer relations
- 7.02 Flexibility of wage determination
- 7.03 Rigidity of employment (hard data)
- 7.04 Hiring and firing practices
- 6.04 Extent and effect of taxation^{1/2}
- 6.05 Total tax rate (hard data)^{1/2}
- 7.05 Firing costs (hard data)

B. Efficient use of talent50%

- 7.06 Pay and productivity
- 7.07 Reliance on professional management^{1/2}
- 7.08 Brain drain
- 7.09 Female participation in labor force (hard data)

8th pillar: Financial market sophistication17%

A. Efficiency50%

- 8.01 Financial market sophistication
- 8.02 Financing through local equity market
- 8.03 Ease of access to loans
- 8.04 Venture capital availability
- 8.05 Restriction on capital flows
- 8.06 Strength of investor protection (hard data)

B. Trustworthiness and confidence50%

- 8.07 Soundness of banks
- 8.08 Regulation of securities exchanges
- 8.09 Legal rights index (hard data)

9th pillar: Technological readiness17%

- 9.01 Availability of latest technologies
- 9.02 Firm-level technology absorption
- 9.03 Laws relating to ICT
- 9.04 FDI and technology transfer
- 9.05 Mobile telephone subscriptions (hard data)
- 9.06 Internet users (hard data)
- 9.07 Personal computers (hard data)
- 9.08 Broadband Internet subscribers (hard data)

10th pillar: Market size17%

A. Domestic market size75%

- 10.01 Domestic market size index (hard data)^h

B. Foreign market size25%

- 10.02 Foreign market size index (hard data)ⁱ

INNOVATION AND SOPHISTICATION FACTORS

11th pillar: Business sophistication50%

A. Networks and supporting industries50%

- 11.01 Local supplier quantity
- 11.02 Local supplier quality
- 11.03 State of cluster development

B. Sophistication of firms' operations and strategy 50%

- 11.04 Nature of competitive advantage
- 11.05 Value chain breadth
- 11.06 Control of international distribution
- 11.07 Production process sophistication
- 11.08 Extent of marketing
- 11.09 Willingness to delegate authority
- 7.07 Reliance on professional management^{1/2}

Appendix A: Structure of the Global Competitiveness Index 2009–2010 (cont'd.)

12th pillar: Innovation.....50%

- 12.01 Capacity for innovation
- 12.02 Quality of scientific research institutions
- 12.03 Company spending on R&D
- 12.04 University-industry collaboration in R&D
- 12.05 Government procurement of advanced technology products
- 12.06 Availability of scientists and engineers
- 12.07 Utility patents (hard data)
- 1.02 Intellectual property protection¹²

Notes

- a The standard formula for converting hard data is the following:

$$a \times \frac{(\text{country score} - \text{sample minimum})}{(\text{sample maximum} - \text{sample minimum})} + 1$$

The *sample minimum* and *sample maximum* are, respectively, the lowest and highest country scores in the sample of countries covered by the GCI. In some instances, adjustments were made to account for extreme outliers. For those hard data variables for which a higher value indicates a worse outcome (e.g., disease incidence, government debt), we rely on a normalization formula that, in addition to converting the series to a 1-to-7 scale, reverses it, so that 1 and 7 still corresponds to the worst and best possible outcomes, respectively:

$$-6 \times \frac{(\text{country score} - \text{sample minimum})}{(\text{sample maximum} - \text{sample minimum})} + 7$$

- b For those groups of variables that contain one or several half-weight variables, country scores for those groups are computed as follows:

$$\frac{(\text{sum of scores on full-weight variables}) + \frac{1}{2} \times (\text{sum of scores on half-weight variables})}{(\text{count of full-weight variables}) + \frac{1}{2} \times (\text{count of half-weight variables})}$$

- c As described in the chapter, the weights are the following:

Weights	Factor-driven stage (%)	Efficiency-driven stage (%)	Innovation-driven stage (%)
Basic requirements	60	40	20
Efficiency enhancers	35	50	50
Innovation and sophistication factors	5	10	30

- d In order to capture the idea that both high inflation and deflation are detrimental, inflation enters the model in a U-shaped manner as follows: for values of inflation between 0.5 and 2.9 percent, a country receives the highest possible score of 7. Outside this range, scores decrease linearly as they move away from these values.
- e The impact of malaria, tuberculosis, and HIV/AIDS on competitiveness depends not only on their respective incidence rates, but also on how costly they are for business. Therefore, in order to estimate the impact of each of the three diseases, we combine its incidence rate with the Survey question on its perceived cost to businesses. To combine these data we first take the ratio of each country's disease incidence rate relative to the highest incidence rate in the whole sample. The inverse of this ratio is then multiplied by each country's score on the related Survey question. This product is then normalized to a 1-to-7 scale. Note that countries with zero reported incidence receive a 7, regardless their scores on the related Survey question.

- f The Competition subpillar is the weighted average of two components: *Domestic competition* and *Foreign competition*. In both components, the included variables provide an indication of the extent to which competition is distorted. The relative importance of these distortions depends on the relative size of domestic versus foreign competition. This interaction between the domestic market and the foreign market is captured by the way we determine the weights of the two components. Domestic competition is the sum of consumption (IC), investment (II), government spending (GI), and exports (IX), while foreign competition is equal to imports (IM). Thus we assign a weight of $IC+I+G+X/(IC+I+G+X+M)$ to *Domestic competition* and a weight of $M/(IC+I+G+X+M)$ to *Foreign competition*.

- g Variables 6.06 and 6.07 combine to form one single variable.

- h The size of the domestic market is constructed by taking the natural log of the sum of the gross domestic product valued at PPP plus the total value (PPP estimates) of imports of goods and services, minus the total value (PPP estimates) of exports of goods and services. Data are then normalized on a 1-to-7 scale. PPP estimates of imports and exports are obtained by taking the product of exports as a percentage of GDP and GDP valued at PPP. The underlying data are reported in the Data Tables section (see tables 10.03, 10.04, and 10.05).

- i The size of the foreign market is estimated as the natural log of the total value (PPP estimates) of exports of goods and services, normalized on a 1-to-7 scale. PPP estimates of exports are obtained by taking the product of exports as a percentage of GDP and GDP valued at PPP. The underlying data are reported in the Data Tables.

6. References - Academic Publications

- Baltagi, B.H. (2005) *Econometric Analysis of Panel Data*. 3rd Edition. John Wiley & Sons, England.
- Bhide, A. (2008) *The Venturesome Economy: How innovation sustains prosperity in a more connected world*. Princeton University Press, Princeton, NJ.
- Brown, R. (2006) The emergence and development of Singapore as a regional/international financial centre, Paper presented to XIV International Economic History Congress, Session 31, Helsinki, Finland.
- Doyle, E. and Fanning, C. (2007) The Role for Clusters in Irish Economic Development Policy, Chapter 16 in Aylward, C., O'Toole, R. (eds.), *Perspectives on Irish Productivity: A Selection of Essays by Irish and International Economists*, Dublin: Forfás, pp. 267-281.
- Doyle, E., O'Connor, F. and Kuah, A. (2009) Innovation Capacities in Advanced Economies: Relative Performance of Small Open Economies. Paper presented at the 12th TCI Annual Global Conference, Jyväskylä, Finland, October 13th, 2009.
- Ellison, G. and Glaeser, E. (1997). Geographic concentration in US manufacturing industries: a Dartboard approach. *Journal of Political Economy* 105 (5):889–927.
- Frei, F.X, Harker, P.T. and Hunter, L. W. (1998) Innovation in Retail Banking, Innovation in Retail Banking, The Wharton Financial Institutions Centre, Paper 97-48-B [available at <http://fic.wharton.upenn.edu/fic/papers/97/9748.pdf>]
- Furman, J., Porter, M. and Stern, S. (2002). The Determinants of National Innovative Capacity. *Research Policy*, 31: 899-933.
- Furman, J.L., Porter, M.E. and Stern, S. (2002) The determinants of national innovative capacity *Research Policy* 31 (2002) 899–933.
- Gans, J. and Stern, S. (2003) Assessing Australia's Innovative Capacity in the 21st Century, IPRIA.
- Gans, J. and Stern, S. (2008) Assessing Australia's Innovative Capacity: 2007 Update, IPRIA.
- Griliches, Z. (Ed.) (1984) *R&D, Patents and Productivity*. Chicago University Press, Chicago, IL.
- Jones, C. (1995) R&D based models of economic growth. *Journal of Political Economy*, 103:739–784.
- Jordan, D. (2009) Re-imagining Innovation: Hold the Scientists and Bring on the Practitioners, *Ivey Business Journal*, 73, 4, pp.1-8.
- Nelson, R.R. (1990) US technological leadership: where did it come from and where did it go? *Research Policy*, Vol. 19.2.
- Pavitt, K. (1982). R&D, patenting, and innovative activities: a statistical exploration. *Research Policy*, 11 (1):33–51.
- Porter, M.E. (1985) *Competitive Advantage: Creating and Sustaining Superior Performance*, New York, Free Press. See pages 212 - 228.
- Porter, M.E.. (1990) *The Competitive Advantage of Nations*. Free Press, New York.

- Porter, M.E., Delgado, M., Ketels, C., and Stern, S. (2008) Moving to a New Global Competitiveness Index, chapter 1.2 in Porter, M.E., and Schwab, K. (editors) The Global Competitiveness Report 2008-2009, World Economic Forum, Geneva, pp. 43-63.
- Romer, P.M. (1990) Endogenous Technological Change, *The Journal of Political Economy*, Vol. 98, No. 5, Part 2: The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems. (Oct), pp. S71-S102.
- Roper, S., Youtie, J. Shapira, P. and Fernandez-Ribas, A. (2009) Knowledge, Capabilities and Manufacturing Innovation: A US-Europe Comparison, *Regional Studies*, forthcoming.
- Roper, S, Du, J. and Love, J.H. (2008) Modeling The Innovation Value Chain, *Research Policy*, 37,6-7, 961-977.
- Trajtenberg, M. (1990). *Patents as Indicators of Innovation, Economic Analysis of Product Innovation*. Harvard University Press, Cambridge, MA.